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GENERAL PHYSICS.

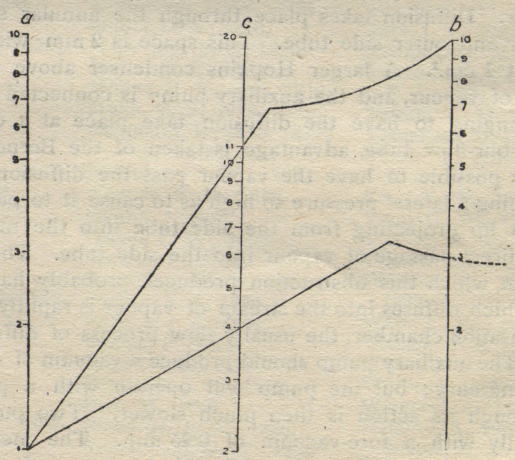
1180. *Mercury-vapour Pump.* **H. B. Williams.** (Phys. Rev. 7. pp. 583–584, May, 1916. Abstract of paper read before the Am. Phys. Soc.)—Describes a very simple form of pump which is much more rapid in action than the Gaede diffusion pump, and which seems to be equally effective in producing extremely low pressures. The vapour passes through a constriction connected to the vessel to be exhausted. Within the connecting side tube is a small Hopkins condenser, whose cooling effect, aided by that of the external air, condenses any vapour which may enter before it has penetrated far. Diffusion takes place through the annular space between the condenser and outer side tube. This space is 2 mm. wide and has an area of about 1 cm.^{2}. A larger Hopkins condenser above condenses the main stream of vapour, and the auxiliary pump is connected to it near the top. By arranging to have the diffusion take place at a constriction in the main vapour-flow tube, advantage is taken of the Bernoulli-effect. It is thus made possible to have the vapour pass the diffusion-point rapidly without reaching a lateral pressure so high as to cause it to pass far into the side tube. A lip projecting from the side tube into the main flow tube hinders the direct passage of vapour into the side tube. The eddies in the vapour stream which this obstruction produces probably hasten diffusion. As the gas which diffuses into the stream of vapour is rapidly carried to the upper condensation chamber, the usually slow process of diffusion becomes very rapid. The auxiliary pump should produce a vacuum of something like 0·1 mm. of mercury; but the pump will operate with a pre-vacuum of 0·25 mm., though its action is then much slower. Two pumps in series operate rapidly with a fore-vacuum of 0·25 mm. The mercury may be heated with a small open flame, or preferably by means of a small electric oven. Effective action does not depend so critically upon precise regulation of temperature as in the Gaede type. The pump is rapid in action. A single pump with a May-Nelson oscillating ring pump as auxiliary exhausted a two-litre bulb with large Al electrodes from atmospheric pressure to a point where the alternative spark-gap measured 18 cm. in 7 minutes. Two vapour

pumps in series connected directly to a McLeod gauge reduced the pressure from approximately 0·25 mm. to 4×10^{-5} mm. in 4 minutes. A short time later the pressure was too low to be measured. A. W.

1181. *New Microbalance.* **E. H. Riesenfeld** and **H. F. Möller.** (Zeits. Elektrochem. 21. pp. 131–136, April 1, 1915.)—The balance is an improvement of the torsion balance of Nernst. A quartz thread, of 12·5 μ diam., is stretched between the prongs of a brass fork, 9 cm. span, brittle sealing-wax serving as cement. To this thread is fastened the beam, a glass capillary 13 cm. in length, the load-arm having a length of 10 cm. For the suspension of the pan the following construction was adopted after trials of various knife-edges. The beam ends in a fork, across which a quartz thread is horizontally stretched; the hook is attached to a second vertical quartz thread. The beam is arrested by being clamped near its end. The balance is sensitive to $3{\cdot}3 \times 10^{-8}$ gm. with a max. load of 5 mgm. All the parts to be suspended in micro-analysis, etc., are fitted with suitable hooks. H. B.

1182. *Henrici Harmonic Analyser.* **D. C. Miller.** (Frank. Inst., J. 182. pp. 285–322, Sept., 1916.)—Gives a full description, with numerous diagrams, of the Henrici analyser, as made by Conradi, of Zurich. An instrument of this type has been in use by the author since 1908 in the study of sound waves, and with it several thousand curves have been analysed. The experience thus gained has led to the development of various instruments and methods for facilitating the analytical work, both with this particular form of analyser and in general. In the present paper a description is given of these devices. Details are also given of an extension of the analyser, which gives it a range of thirty components. A. W.

1183. *Logarithmic Plotting of Alignment Charts for Additive Expressions.* **C. E. P. Sankey.** (Inst. Civ. Eng., Proc. 201. pp. 370–390, 1915–16.)—



In plotting alignment charts for expressions of the form $a + b = c$ supports bearing even graduations are usually employed. For expressions of the form $a \times b = c$ logarithmic scales are employed, and they have the advantage that the proportionate error is the same at all readings. In the present paper it is shown how logarithmic scales, retaining this advantage, can be used for the

additive expression $a + b = c$. This end is achieved by a special transversal, consisting of straight and curved portions, which is drawn on a transparent medium. Two forms of the transversal are possible; one of them is shown in the Fig. herewith. With the transversal shown the end of the straight portion must always be applied to the left-hand support. The original contains formulæ and tables for plotting the curved part of the transversals.

F. T. C.

1184. *Measurement of Time with a Moving-coil Galvanometer.* **P. E. Klopsteg.** (Phys. Rev. 8. pp. 195–206, Aug., 1916.)—A method is developed for the measurement of time intervals by means of a short-period galvanometer under two conditions of damping, viz. slight damping and critical damping. It depends on the elongation resulting from a steady current sent through the instrument during the interval to be measured. The first method may be used for intervals approaching the half-period of the coil, with an accuracy of about 0·3 %. The method which makes use of the critically damped condition is useful for intervals of at least the same length, with an accuracy which is dependable to almost 0·1 %, provided a shunt of proper resistance is used to make damping exactly critical. A table is given which simplifies the calculations of this method, and an equation is also given by means of which the critical damping resistance may accurately be determined. [See Abs. 932 (1916).] A. W.

1185. *Apparent Periodicities of Accidental Phenomena.* **T. Terada.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 492–496, July, 1916.)—The present note is chiefly intended to draw the attention of seismologists and meteorologists to the existence of apparent quasi-periodicity in accidental phenomena, which sometimes might be mistaken for periodicities with real physical significance. A. W.

1186. *Semi-automatic High-pressure Installation.* **Berkeley** and **C. V. Burton.** (Phil. Mag. 32. pp. 153–161, July, 1916.)—A detailed description of a special piece of apparatus which is to be used in a research later to be described. For further information the original should be referred to.

L. H. W.

1187. *Speed Sighting and Wind Deflection in Artillery.* **G. Greenhill.** (Engineer, 122. pp. 133–134, Aug. 18, 1916.)—Discusses, with the aid of several diagrams, the way in which the back- and fore-sights on guns should be adjusted to allow for motion of either target or platform, or of both together. The theory is based on the principle of relative velocity.

A. W.

1188. *Theory of the Stiffness of Elastic Systems.* **M. D. Hersey.** (Washington Acad. Sci., J. 6. pp. 569–575, Oct. 4, 1916.)—The author in his introduction states that instead of treating stiffness directly, writers on elasticity make a detour, first determining the strain distribution throughout the interior of the body, which procedure limits the validity of the result to certain rather simple geometrical shapes. While such detailed analysis is indispensable for some purposes, the author shows in the present paper that this is by no means true for all, and though he presents some examples in connection with the aneroid barometer yet his procedure is not confined to that particular elastic system. The stiffness of coupled systems first comes under review, the influence of temperature and elastic after-effect being considered;

this leads to a general expression for the stiffness S of a body, where for a series of perfectly elastic bodies of different sizes or materials but of the same generalised shape, $S = LE\phi(\sigma) = L\mu\psi(\sigma) = Lf(E, \mu)$, in which L denotes any chosen linear dimension, E Young's modulus, μ the rigidity (*i.e.* shear modulus), and σ Poisson's ratio. The functions ϕ, ψ, and f are to be found, if they need to be known at all, by detailed calculations employing the conventional theory of elasticity, or by model experiments. The change in stiffness with temperature, and criteria for compensation are next dealt with; in the expressions found it is significant that there are no terms inseparably involving both shape factors and thermal properties, so that the complete expression for the effect of temperature on the stiffness of a body made of a material whose temperature coefficients are known, can be developed empirically without changing the temperature. Simplified expressions for homogeneous isotropic bodies are given together with a series of numerical results in particular cases. H. H. Ho.

1189. *Cohesion.* II. **H. Chatley.** (Phys. Soc., Proc. 28. pp. 307–314, Aug. 15, 1916.)—In his earlier paper [Abs. 1489 (1915)] the author suggested that certain empirical formulæ could be employed for the representation of the force between molecules known as cohesion, and in the present paper this treatment is extended and various correlated facts and theories are discussed. The principal formula suggested is:

$$\text{Cohesion} = \text{attraction} - \text{repulsion},$$
$$t = k_2 d^{-\gamma_2} - k_1 d^{-\gamma_1},$$

where t is the cohesive bond between two molecules, d the distance between the centres of the molecules, and k_1, k_2, γ_1, and γ_2 are coefficients; k_1 and k_2 vary with the substance, k_1 (perhaps k_2 also) increases with rise of temperature, and all are functions of d, but within narrow limits may probably be regarded as constants. Various special cases are discussed. As regards the magnitude of the attraction, it is found that at molecular distances the "gravitational" force is increased about 10^{30} times, and it is interesting to note that this ratio is about the same as that of the electrostatic and gravitational attractions of two atoms. This result appears to indicate that the force of cohesion is comparable with the electrostatic forces between atoms, *i.e.* chemical affinity. Nernst and Lindemann (see Nernst, "Theory of the Solid State," p. 4) are of this opinion but from other reasons.

The outstanding difference between chemical affinity and cohesion lies in the selective character of the first. So far as the ability of valency bonds of an atom to hold a molecule is concerned, this is a common feature in organic compounds; what is distinct in the selective process is the feature of "saturation." The case of silica is considered. (1) In each sub-molecule, SiO_2, the four valency bonds of the silicon atom are linked in pairs to two oxygen atoms, this being purely chemical. (2) The sub-molecules are linked in pairs, if Nernst's formula $(SiO_2)_2$ is correct; this is chemical in so far as it occurs in constant proportions, but is cohesive in so far as it is the linkage of molecules as distinct from atoms. (3) The silica molecules are linked to one another irrespective of quantity, but with a configuration of maximum stability (crystal) with four axes (hexagonal system). Linkage can occur without geometrical form (amorphous solid). The magnitude of the linkage forces is inferior to that of (1) and (2), but not incomparably so (cohesion). (4) If gravitation is not a particular case of cohesion, there is, in addition, a small mutual attraction with no vector quality in accordance with

Newton's law. It would seem possible to deduce from the fields about different stable systems of differently charged spheres some idea as to the feasibility or otherwise of explaining cohesion on these lines. T. H. P.

1190. *Viscosity of Suspensions of Rigid Particles at Different Rates of Shear.* **E. Humphrey** and **E. Hatschek.** (Phys. Soc., Proc. 28. pp. 274–282, Aug., 1916.)—The work here described was undertaken with a view to testing the Einstein-Hatschek formula at variable rates of shear; acording to this formula the viscosity of a suspension of rigid spherical particles grows in linear ratio with the aggregate volume of suspended particles. Determinations of the viscosity of suspensions of starches of different origins (and sizes) were made by Harrison (1911), who found that the increase in viscosity is independent of the size of the particles and in linear ratio to the volume as found by centrifuging the suspension and reading the total volume occupied by the granules. On the other hand, Oden (1912) used a sulphur sol and found that the viscosity of more concentrated solutions increases more rapidly than the concentration, and also that, the more disperse the sol (the smaller the particles), the greater the viscosity. Some of these discrepancies seemed due to the use of the capillary viscosimeter, and the present investigation was undertaken with Hatschek's modification of Couette's apparatus, which allows of a variation in the rate of shear. The suspension employed was one of rice starch (granules about 0·003 mm. in diam.) in a mixture of carbon tetrachloride and toluene, the amounts of the two liquids being adjusted so that the starch granules remained suspended for several hours. The systems examined were 0, 2, 4, and 6 % suspensions by volume, and the angular velocities varied roughly from 20° to 180° per sec., corresponding with linear velocities of the revolving cylinder of 1·9–17·2 cm. per sec. The most noticeable result of the whole set of determinations is the marked dependency of the viscosity on the rate of shear; this is much greater at lower rates, but tends to approach constancy at rates above a certain limit, the latter itself increasing with the concentration of the suspension.

The deviations from the formula are, indeed, of two kinds, the increase in relative viscosity being more than linear, especially at low rates of shear, and the proportionality factor being much greater than the figure found theoretically. As regards the latter, the difference between the irregular polyhedral granules of the starch and spherical particles may be sufficient to account for the discrepancy. The more than linear increase seems to indicate that the assumption on which both Einstein's and Hatschek's deductions are based, namely, that the particles do not influence one another, is untenable. One possible source of error in the experiments may lie in the presence of imbibed water in the starch granules, the latter possibly being incompletely wetted by the medium. T. H. P.

1191. *Mercury Droplets and Electronic Charge.* **L. W. McKeehan.** (Phys. Rev. 8. pp. 142–148, Aug., 1916.)—This work is incidental to additional investigation of the correction to Stokes' formula in gases, using mercury spheres. The experiments show that constancy of mass is incompatible with the continued purity of the material in a gas, and that hitherto neglected chemical properties of the metal profoundly modify its behaviour in this state of subdivision without correspondingly important changes in the appearance of the drops.

The rate of evaporation from a clean mercury surface at the average temperature of experiment is more than sufficient to account for the max.

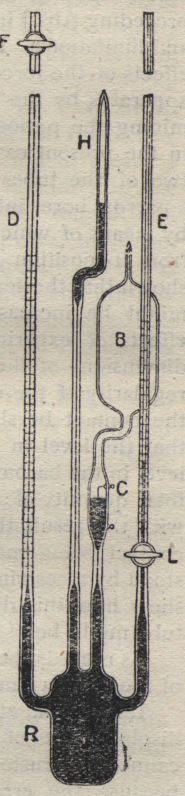
rate of decrease observed. It appears that diffusion of the vapour is able to keep its partial pressure in the neighbourhood of an isolated sphere of the size used, very far below the saturation pressure. E. H. B.

1192. *Vibratory Whirls in Air.* **L. Périssé.** (Soc. Ing. Civ. de France, Bull. pp. 27–44, 1916. Génie Civil, 68. pp. 233–235, April 8, 1916. Abstract.) —This paper refers to experiments carried out by C. Weyher more than 25 years ago, and to his theory of the formation of vibratory vortices in air due to the motion of a blade-wheel with the blades disposed longitudinally through the axis of rotation. The efforts by which the air streams were made visible are described in detail. It has been found that two kinds of air streams are formed : first, helicoidal centrifugal spires, going from the equator of the rotating sphere to each pole ; and second, helicoidal centripetal spires going from the poles to the equator. The paper describes in some detail experiments made to determine the properties of attraction and repulsion of aerial whirls as compared with magnetic bodies. It was found that when two blade-wheels rotate in opposite directions they tend to attract, because with the air streams of the whirl moving in the same direction between the blade-wheels, the air tends to become rarefied between them, and the external pressure makes them come together. If, however, the wheels rotate in the same direction, the tendency is for repulsion. From his experiments Weyher concluded that the mechanism of vorticular motion is as follows :—The gas does not simply rotate in a single path about its axis, but is broken up into an infinite number of streams separate from one another ; each of these streams describes helicoidal screw paths, some having a right-hand and some a left-hand thread, some centripetal and others centrifugal. This amounts to saying that the air streams cross one another on through the space, moving in opposite directions and mutually avoiding each other, but producing as many vibrations as there are crossings of paths, *i.e.* an infinite number. An interesting experiment is described showing that this particular mechanism may apply to the case of ether. The paper also contains applications to the problems of the physics of the ether and wireless telegraphy. H. H. Ho.

1193. *Mechanical Representation of Electric and Magnetic Phenomena and the Theory of Relativity.* **D. Berthelot.** (Soc. Ing. Civ. de France, Bull. pp. 55–63, Jan.–March, 1916. Rev. Élec. 25. pp. 246–250, April 21, 1916.)—Emphasises the essential duality (translational and rotational) of electric and magnetic phenomena ; no one mechanical representation is sufficient, whence we are led to two systems, electrostatic and electromagnetic, which give electric and magnetic quantities in terms of fractional powers of L, M, T. If we try to give K and μ dimensions which bring L, M, and T to integral powers, we find that alternatively K is an elasticity and μ a density, or *vice versa* ; and we have no real means of determining between these alternatives. Similarly the question of the direction of the vibrations of the ether is still unsettled ; so is the question whether electric energy is potential and magnetic kinetic, or *vice versa*. The development of forces due to motion, etc., have no analogy in Newtonian mechanics ; either of the two fields, considered alone, can easily be represented by a mechanical model, but not the relations of the two fields. We cannot express electromagnetic phenomena in terms of the primary concepts of ordinary mechanics. But this indicates that those physicists have gone too far who have used the principle of relativity to modify these concepts from electromagnetic data. Their inference that the velocity of light is a limiting velocity is too radical ;

longitudinal vibrations of the ether might travel more rapidly than light does; seismic disturbances travel more rapidly than sound-waves in the earth, and explosion-waves in the air may travel far faster than sound-waves; and it is not impossible to conceive terrestrial experiments involving velocities of propagation exceeding that of light. A. D.

1194. *Apparatus for the Determination of Gravity at Sea.* **W. G. Duffield.** (Roy. Soc., Proc. 92. pp. 505–517, Sept. 1, 1916.)—The apparatus which was adopted after preliminary experiments by the author is shown in the Fig., and the principal dimensions are given in a table. A constant volume of air is maintained in the bulb B by keeping the mercury always up to the pointer at C. The air in the bulb is under reduced pressure in order to keep the apparatus within reasonable dimensions. The barometer tube is bent so that H is vertically above C, the length of the column of mercury HC being approximately 20 cm. The level is kept at C by raising or lowering the level of the mercury in the index tube D (of fine bore and graduated in cm.) by means of an exhaust pump. From the reading of the level of the mercury in this tube, when contact is made with the pointer at C, the value of gravity can be calculated. The other side tube E is of wider bore, and is used only for making the initial adjustment at the beginning of the voyage. It was introduced on account of the great difficulty of correctly adjusting the amount of mercury in the apparatus, and to enable it to be used for various ranges of temperature. From the dimensions which are given in the original, it is calculated that a change of level of 1 mm. in the index tube is equivalent to a change in the value of gravity of 0·058 cm./sec.^{2}.



Between lat. 0° and 54° a movement of the mercury in the index tube of about 60 mm. is required. To maintain the whole apparatus at as uniform a temperature as possible, it is immersed in water in a stout zinc vessel. This is suspended by cords from the ceiling of the refrigerator on board ship. The motion of the vessel keeps the water stirred, and before making readings it is further agitated by pumping air through it by means of a bicycle pump. The moment of contact of the mercury with the pointer at C is detected electrically by means of a trembler coil and telephone.

The readings are made in the following manner:— By means of the hand Fleuss pump a vessel V is partially exhausted. It is then placed in communication with the index tube D, and the level of the mercury in that tube raised to about 3 cm. above the level at which contact had occurred during the previous experiment. The mercury in the contact tube is then below the pointer, and the telephone is silent. A two-way tap is then turned, and air gradually admitted to the index tube D through a tube, which is fine-drawn to prevent the thread of mercury from moving too rapidly. The mercury falls slowly in the index tube until the level of mercury in the contact tube has been raised sufficiently for the telephone circuit to be completed.

The contact error and the temperature correction are discussed at length in the paper, as is also the error due to the introduction of capillary tubing (necessary to prevent "pumping").

The value of Δg was calculated from the knowledge that the area of the barometer tube was 84·5 times that of the capillary index tube, and that the instrument was designed for a mercury column 20 cm. in height, where gravity has the value 981.

Interesting observations were carried out with the apparatus on a voyage to Australia in 1914. E. O. W.

1195. *On the Determination of Gravity at Sea.* (Note on Duffield's paper.) **A. Schuster.** (Roy. Soc., Proc. 92. pp. 517–528, Sept. 1, 1916.)—The author enters upon a discussion on the theoretical side of Duffield's method [see preceding Abs.] in order that an opinion may be formed as to its capabilities and limitations. For this purpose it is especially necessary to investigate the effects of the forced vibrations which may be imposed on the mercury in the apparatus by the vertical acceleration of the ship. The problem of determining the period of free oscillation in a barometer tube is very simple, but in the present case three tubes are connected with each other, and at least two of the tubes are not of uniform section, but contain a portion with a narrow bore, introduced to damp the oscillations. An equation is derived by means of which the motion of the mercury in the three tubes if disturbed from its position of equilibrium and left to itself may be determined. It is shown that the length of the capillary in the contact tube is too small and might be increased in future designs. Investigation is made as to the effects of experimental errors so far as they are affected by the relative dimensions of the various parts of the apparatus. Much depends upon the regularity of the electrical contact. Small variations must be expected. If the contact be slightly delayed owing to a speck of dust or otherwise, so that the level in the contact tube is too high when the signal is given, the level in the barometer tube will be too high by the same amount, so that the total quantity of mercury in the two tubes will exceed the proper amount, with the result that the level in the index tube will be the same as if, the contact being made at the right time, the mercury in the barometer tube stood by a certain amount above its correct height. The author goes on to show how this difficulty might be overcome. The capillary in the contact tube might be of smaller bore.

As regards the error due to the vertical motion of the ship, the oscillation of the mercury may cause the contact to be accelerated or retarded.

Insufficient attention, the author thinks, has been given to the angular displacements of the barometer system, which, owing to the ship's motion, cannot be trusted to remain perfectly vertical. The matter is important, because the error cannot be eliminated by repeating the observations. Whether the deviation be to the right or left, the mercury will always rise in the barometer tube, and for a deviation α the apparent height of the barometer will be $h/\cos\alpha$, when its real height, *i.e.* the vertical difference of level in the barometer and contact tube, is h. A deviation of 1° would consequently cause an error of $1{\cdot}5 \times 10^{-4}$ in the value of $\delta g/g$. To reduce the error to 2×10^{-5}, the barometer system should never deviate more than 22 minutes of arc from the vertical. E. O. W.

1196. *On the Special Gravitation of the Electric Field given by Einstein's Theory.* **H. Reissner.** (Ann. d. Physik, 50. 1. pp. 106–120, June 6, 1916.)—By

his explanation of the motion of the planet Mercury, Einstein has demonstrated the fruitfulness of his new covariant field equations of gravitation, and therewith the postulate of general relativity. In addition, Einstein has given the general covariant expression for the Maxwell-Lorentz equations. The present author has taken as the next problem the investigation of the influence of this special gravitation in an electric field assumed for simplicity to be spherically symmetrical. The paper first deals with the tensor of the electrostatic field, after which the field equations are developed and their integration discussed. The integration constants are next treated at some length, and finally the gravitational field of an uncharged spherical mass at rest is investigated. The author attempts to find a statical union of charged elements by means of this special gravitation, without taking Maxwell's theory as a basis, and he has established that the Einstein gravitation, *i.e.* the field of the electrically charged elements, is distorted to a definite but abnormally small degree. H. H. Ho.

1197. *Results of Registering Balloon Ascents at Batavia.* **W. van Bemmelen.** (Review in Nature, 98. p. 21. Sept. 7, 1916.)—Ascents of registering balloons were made on 103 occasions from 1910 to 1915, and of these 66 furnished available records. Tables of temperature and humidity in the free atmosphere are given, and there is a discussion of the diurnal and seasonal variations. Eighteen ascents reached the stratosphere, the mean height of which is just under 17 km. at Batavia. The freezing-point is reached at 4·7 km.; at 10 km. the temperature is 239° Å., at 17 km. the low value of 189°A. is found. The corresponding values over England at 10 and 17 km. are 222° and 219° Å. On one occasion a temperature of 183° Å. was reached at 16·7 km.

The standard deviation of the mean values is small, so that there is no room for serious error in the average values. [This monograph is published by the Batavia Javasche Bockhandel en Drukkerij, 1916.] R. C.

1198. *Diurnal Variation of Atmospheric Electrical Quantities.* **E. H. Nichols.** (Phil. Mag. 32. pp. 282–294, Sept., 1916.)—Describes the results of hourly observations of electrical elements at Kew Observatory in May, June, and July, 1914, which were made during the daytime on four days in each month, by means of the Wilson portable electrometer. The curve showing the mean diurnal variation of the positive charge per cm.^{3} shows a maximum at 11 a.m., while that for the conductivity gives a maximum at 2 p.m. The air-earth current shows little variation, but the mobility of the ions gives a decided increase after noon. The potential shows a definite minimum in the afternoon, and agrees closely with the normal for 1898 to 1912 for those months on electrically quiet days.

Results of similar observations made at Eskdalemuir in Aug. 1914, including hourly measurements on Aug. 21, when a partial solar eclipse occurred, are also described. R. C.

1199. *Twilight Phenomena.* **P. Gruner.** (Archives des Sciences, 42. pp. 32–46, July, 1916.)—A scheme is proposed for the systematic observation of twilight sky colours, both near and opposite to the sun, with detailed instructions for the various physical phenomena to be noticed. C. P. B.

1200. *Change in the Composition of the Atmosphere with Height.* **A. Wigand.** (Phys. Zeits. 17. pp. 396–400, Sept. 1, 1916.)—In 1911–12 the

author made 4 balloon ascents from Bitterfeld up to 9000 m. and collected 11 samples of air, some of which E. Erdmann and A. Lange analysed by the Erdmann method of fractionated condensation. Only four analyses could be made before the war, however, and the results are published now because the completion of the analyses is doubtful. There were further available 21 analyses, carried out by the same experimenters and by Haschek, of air samples collected in 1910 when Halley's comet was approaching the earth, in balloon ascents from Lindenberg (7) and from Vienna (14). The author collected his samples in glass bottles of 2 litres' capacity ending below in two thick-walled fine tubes, one sealed after evacuation, the other provided with a three-way tap. To the latter an Al tube, 30 m. long, 7 mm. external diam., could be attached in 20 sections. Special precautions were taken to prevent contamination of the air collected by the CO_2 exhaled by the aeronauts and by the hydrogen from the balloon. The analyses concern CO_2; He, Ne, and H (together); and also H (spectroscopic). The CO_2 percentage decreased, the proportion of the other gases increased, as the height above the earth's surface increased to 9 km., from 22·8 to 33·7 mm.^{3} per litre. The weather conditions were sometimes cyclonic; but the material is insufficient for drawing conclusions. H. B.

1201. *The Sakura-Jima Eruption of January, 1914.* (Imp. Earthquake Investig. Committee, Bull. 8. pp. 35–179, 1916. Abstract by C. Davison in Nature, 98. pp. 57–58, Sept. 21, 1916.)—Omori has recently published a second valuable memoir on the eruption of Sakura-Jima. The volcano lies in Kagoshima Bay in South Japan. Formerly an island, it is now connected by a lava stream to the land. The eruption appears to have caused a depression of the ground in the neighbourhood. The point of maximum depression, which probably coincides with the principal centre of the lava reservoir, lies, not under Sakura-Jima, but in the region between it and the active volcano of Kirishima.

The triangulation surveys of 1898 and 1914 also reveal considerable displacements, both horizontal and vertical, in Sakura-Jima, while the coast of the island is everywhere depressed. Three points in the interior have been raised 0·14 and about 9·7 and 10·4 m. The horizontal displacements in the north-west of the island vary from 2·04 to 3·62 m. towards the south, and in the west and north by amounts from 1·08 to 4·52 m. towards the north and north-east. The north and south portions of Sakura-Jima have thus been displaced outwards in contrary directions. Moreover, displacements of 0·53 to 0·95 m. along the west coast of Kagoshima Bay converge with those in the west and north of Sakura-Jima towards an elliptical area which agrees roughly with the area of greatest depression. Sounds were heard within two entirely detached areas similar in form and to some extent in magnitude. The width of the silent zone was 40 to 50 km. for the strong detonations, and about 108 km. for the after-explosions. The greatest distance at which the detonations were heard was about 500 km. towards the N.E., but the air vibrations were strong for about 85 km. farther in the same direction.

E. O. W.

1202. *Movements of the Earth's Pole.* **E. H. Hills.** (Nature, 97. pp. 530–535, Aug. 24, 1916. Discourse delivered at the Roy. Inst., May 19, 1916.)—The progress of investigation in the study of variation of latitude is summarised from the time when Chandler and Küstner made their important observations (1884), to the later results obtained by the International Latitude Bureau. [See Abs. 1210 (1915).] C. P. B.

1203. *Atmospheric Transmission.* **F. W. Very.** (Science, 44. pp. 168–171, Aug. 4, 1916.)—A lengthy criticism is made of the observations by Abbot at Mt. Wilson from which the variability of solar radiation has been inferred. It is emphasised that the variations of terrestrial atmospheric transmission are considerable, mainly due to the large movements of water-vapour near midday. Details are also given of the author's work on the comparison of intensity of earth-shine, moonlight, and skylight in connection with the same problem. C. P. B.

1204. *Oil Drive for Equatorial Telescope.* **S. Bolton.** (Nature, 98. pp. 28–29, Sept. 14, 1916.)—An oil regulator invented by G. H. Denison, of Leeds, has been successfully employed for driving the 26-in. equatorial reflector used by the author in his astronomical work. The oil cylinder is arranged vertically near the telescope pillar, and the motion of the piston is transmitted to the polar axis by a cord passing over suitable pulleys. The rate of motion is controlled by a valve permitting the passage of oil from the cylinder to a reservoir placed above it. As arranged, the regulator runs for 3 hours before needing rewinding. An oil possessing a high flash-point is most suitable, as the change in viscosity under different temperatures is then not great. Small errors in driving are found, but it is hoped to reduce them by suitable additions to the apparatus. C. B. P.

1205. *Planetary Influence on Solar Activity.* **V. Kostitzin.** (Comptes Rendus, 163. pp. 202–204, Aug. 21, 1916.)—A short discussion is given on the possibility that the variations of solar activity may be due to planetary influence, or are to be looked for in consequence of the initial conditions of the primitive nebula from which the solar system is considered to be derived. C. P. B.

1206. *Large Solar Prominences.* **J. Evershed.** (Observatory, No. 504. pp. 392–393, Sept., 1916.)—Large solar prominences have been recorded somewhat frequently in the present cycle. One recorded visually by Fenyi on 1915 Dec. 23, and another photographed in Kashmir have been greatly exceeded by an eruption photographed in Kashmir on 1916 May 26, at latitude + 45° to + 65° on the east limb. The actual measured height of the highest point is 18·5 mins. of arc, or 500,000 miles. It seems characteristic of this type of prominence that the outermost parts leave the sun with accelerating velocity, and fade away to invisibility in a few minutes. C. P. B.

1207. *Relative Luminosities of Sun and Stars.* **C. T. Whitmell.** (L'Astronomie, Aug., 1916. Nature, 97. p. 528, Aug. 24, 1916. Abstract.)—Assuming the sun's stellar magnitude to be —26·5, and denoting the luminosity, parallax, and magnitude of the star by L, p, m, the luminosity of the star in terms of that of the sun may be calculated from the equation $\log L = 0{\cdot}0289 - 2 \log p - 0{\cdot}4\, m$. The constant term depends upon the value assigned to the sun's stellar magnitude. C. P. B.

1208. *Influence of Venus on Sun-spot Latitudes.* **H. Arctowski.** (Comptes Rendus, 163. pp. 121–122, July 31, 1916.)—Examination of the Greenwich sun-spot records from 1874–1913 shows a variation in the mean spot latitude for selected rotations, to an extreme value of 7°, but there is a large difference of phase between the path of Venus in latitude and the oscillation of spot latitudes, rendering it difficult to decide whether the effect is inverse or direct. [See Abs. 132 (1912).] C. P. B.

1209. *Anomalous Dispersion in the Sun.* **S. Albrecht.** (Astrophys. J. 44. pp. 1–14, July, 1916.)—In an earlier paper [Abs. 1220 (1915)] the author showed that lines in the solar spectrum which have close companions of sufficient intensity are displaced relatively to their positions obtained in laboratory spectra, and that these displacements show considerable agreement with the requirements of the anomalous dispersion theory. This view was doubted by Royds and Evershed [Abs. 296 (1916)]. The author now presents a discussion of the displacements grouped according to whether both components of the close double are due to the same element or to different elements, the shifts in the former case being double those in the latter category. [See also Abs. 1006 (1916).] C. P. B.

1210. *Double Occulting Shutter for Stellar Photographs.* **O. J. Lee.** (Astrophys. J. 44. pp. 59–61, July, 1916.)—A special form of double-disc rotating sector has been devised for reducing the intensity of bright stars when needed for measurement with neighbouring faint stars for parallax measurement. The discs are arranged as differential wheels with 99 and 100 teeth, giving a "creep" of one revolution in 100. Varying apertures may be used. It was found possible to get measurable images of Sirius and Procyon with 5-minute exposures, the star discs being reduced to below those corresponding to 8·5 magnitude. C. P. B.

1211. *Hydrocarbon Origin of Fraunhofer's G Band in the Solar Spectrum.* **H. F. Newall, F. E. Baxendall,** and **C. P. Butler.** (Roy. Astron. Soc., M.N. 76. pp. 640–641, June, 1916.)—The characteristic band with head at λ4314 in the solar spectrum has been identified with the band shown in the candle-flame spectrum at that position. The band is of considerable importance in the interpretation of celestial spectra, exhibiting marked changes in excessive types of stellar spectra. A reproduction is given from a photograph of the spectrum of the blue cone at the base of a Méker burner flame, in comparison with the solar spectrum with the same instrument. Superposed spectra of an iron arc are included for check during the long exposure on the flame spectrum (12 hours). C. P. B.

1212. *Temperature and Radiation of the Sun.* **C. G. Abbot, F. E. Fowle,** and **L. B. Aldrich.** (Astrophys. J. 44. pp. 39–44, July, 1916.)—The paper is mainly a criticism of a paper by Biscoe, whose assumption of a sharply-defined "black-body" photosphere radiating through a thin gaseous envelope taking little part in the radiation is regarded as untenable. With respect to the suggestion that the variability of the solar radiation as observed at Mount Wilson and Bassour is probably due to variations of terrestrial atmospheric transmission, the authors repeat their belief in the reliability of their results, and show that it is supported by several different investigations. [See also Abs. 757 (1916).] C. P. B.

1213. *Solar Radiation and Melting of Polar Caps of Mars.* **E. M. Antoniadi.** (Roy. Astron. Soc., M.N. 76. pp. 643–645, June, 1916.)—Examination of the records of the melting of the polar caps of Mars from 1862 to 1914, furnishes satisfactory evidence of a relation between the phenomenon and the changes in the solar activity. Details of the principal cases are given. With a few exceptions, due to local causes on the planet, the melting of the polar caps is accelerated when sun-spots are numerous and retarded when they are few. A diagram is given showing the close relationship between the two phenomena.

1214. *Meteorology of the Moon.* **W. H. Pickering.** (Monthly Weather Rev. 44. pp. 70–74, Feb., 1916.)—Attention is drawn to the fact that the popular belief in the idea of the moon's features being unaltered during historical time is not in agreement with the expressed opinion of all the more noted lunar observers. Drawings are given showing changes seen in the form of several bright spots on the mountain Pico, from which it is inferred that the whiteness is due to snow, possibly produced by the freezing of water-vapour issuing from rents in the lunar crust. C. P. B.

1215. *Photographic Measurement of Canals of Mars.* **G. H. Hamilton.** (Observatory, No. 504. pp. 363–367, Sept., 1916.)—A drawing is given showing details measured on a photograph of Mars taken by Lowell on 1916 March 15. Many canals, some double, are certified to be distinctly seen, and equations are provided for reducing the rectangular coordinates of the measures to latitude and longitude on the planet. C. P. B.

1216. *Variable Nebula in Corona Australis.* **J. H. Reynolds.** (Roy. Astron. Soc., M.N. 96. pp. 645–646, June, 1916.)—The nebula N.G.C. 6729, in Corona Australis, was discovered by Marth at Malta, and independently by Schmidt at Athens, the latter suspecting its variability. Photographs taken at the Helwan Observatory by Knox-Shaw leave little doubt as to the variability. The region is a very remarkable one, containing a large bright globular cluster (N.G.C. 6723), an irregular nebula (N.G.C. 6726, 6727) containing two stars of 6·7 and 8 mag. and the three variable stars R, S and T Coronæ Australis, while there is a comparative absence of stars in and around the nebulous region. The nebula varies both in brightness and form. **H. Knox-Shaw.** (Roy. Astron. Soc., M.N. 76. pp. 646–647, June, 1916.)—Further information is given beyond that available in the note by Reynolds, and four of the photographs are reproduced, showing the variability very clearly. There seems to be no simple relation between the form of the nebula and the magnitude of the variable R, although the nebula is brightest when R is brightest. Variations of a faint star south-following the nebula suggest the possible action of an absorbing medium, but of this there is at present no reliable evidence. C. P. B.

1217. *Period of U Cephei.* **M. B. Shapley.** (Astrophys. J. 44. pp. 51–58, July, 1916.)—The available observations of this variable are discussed with regard to the possibility of a change in the period, the variations from elements predicted by different formulæ being shown in diagrams. The variation appears to consist of a definite change in the length of the light-period rather than alteration of the width of the minimum, or changes of the comparison star. Wendell's elements seem best as a working formula at present, but would probably predict minima too early. C. P. B.

1218. *Continuous Spectrum of Stars in Relation to Absolute Magnitude.* **G. S. Monk.** (Mt. Wilson Solar Observatory, Contrib. No. 119. Astrophys. J. 44. pp. 45–50, July, 1916.)—Adams has already shown that stars of small proper motions are relatively weaker in the more refrangible portion of the spectrum [Abs. 832 (1914)]. It was found that the difference increases with advancing type from F to K. The work has been continued by comparing the density of the continuous spectrum of various stars with standard exposures on the spectrum of Arcturus. The conclusion is that the greater part of the effect is due to differences of absolute magnitude rather than to absorption of light in space. C. P. B.

1219. *Systematic Motions of K-type Stars.* **S. C. Meijering.** (Review in Observatory, No. 504. p. 396, Sept., 1916.)—The author has investigated the motions of the K stars in Boss's catalogue according to the two-drift theory. The results appear in agreement with those obtained from a discussion of all the stars in the catalogue without distinction of type. Although the third drift is not mentioned, it is shown in the diagrams accompanying the memoir. The thesis is in English [published by Hoitsema, Groningen].
C. P. B.

1220. *Maxima of Mira Ceti in* 1915. **F. de Roy.** (Soc. Spettroscop. Ital., Mem. 5. July, 1916. Nature, 98. pp. 21–22, Sept. 7, 1916. Abstract.)—Observations of this variable were made from 1914 Nov. 21 to 1916 March 8, and the maxima were found to be on 1915 Jan. 25 (mag. 3·8), and 1915 Dec. 20 (mag. 3·0), with a minimum on 1915 Aug. 22 (mag. 8·7). The first maximum was a low one, and the minimum a high one; the second maximum was about normal.
C. P. B.

1221. *Faint Star with Large Proper Motion.* **E. E. Barnard.** (Nature, 98. p. 22, Sept. 7, 1916.)—Examination by the blink-microscope of photographs taken with the 10-in. Bruce telescope at Yerkes resulted in the detection of a faint star (11 mag.) having an annual proper motion, in a northerly direction, of 10 secs. of arc. The star's position is RA=17h. 53m. 44s.; Decl. = + 4° 27·4′ (1916·0). The motion is confirmed by plates taken at Harvard.
C. P. B.

1222. *System of Polaris.* **L. Courvisier.** (Astron. Nachr. 4854. Nature, 98. p. 22, Sept. 7, 1916. Abstract.)—It is announced that a discussion of available observations gives evidence that the visible 9th mag. companion to Polaris is a member of the system, making it quadruple. The period of this component is given as 20,000 years; the other two companions have periods of 4 days and 12 years respectively.
C. P. B.

1223. *Distribution of Stars in Globular Clusters.* **A. S. Eddington.** (Roy. Astron. Soc., M.N. 76. pp. 572–585, May, 1916.)—A lengthy discussion is given of the significance of the law of density found by Plummer and H. v. Zeipel to govern the distribution of stars in globular clusters [see Abs. 312 (1916)].
C. P. B.

1224. *Radiation-pressure and Rotation of Celestial Bodies.* **T. Bialobjeski.** (Comptes Rendus, 162. pp. 782–784, May 22, 1916.)—A short discussion is given of the possible reactive effect of radiation-pressure on the velocity of rotation of the body emitting the light radiation, with special reference to the observed laws of rotation of the solar surface and atmosphere as determined by different methods.
C. P. B.

1225. *Detection of Proper Motions with Blink-microscope.* **R. T. A. Innes.** (Union Observatory of S. Africa, Circ. No. 35. pp. 269–278, June 24, 1916.)—Detailed notes are given of the measurement of 9 pairs of plates taken at Greenwich, with intervals from 18 to 22 years, and of 1 pair taken at the Cape with interval of 21 years. The detection of proper motions was made very quickly with the blink-microscope, and the results are given in a table showing values for 14 stars.
C. P. B.

LIGHT.

1226. *Scattering and Regular Reflection of Light by an Absorbing Gas.* **R. W. Wood** and **M. Kimura.** (Phil. Mag. 32. pp. 329–344, Sept., 1916.)—In previous papers [Abs. 1182 (1912)] it has been shown that mercury vapour, at room temperature, in an exhausted quartz bulb, when illuminated by the light of a quartz mercury arc, re-emits diffusively a monochromatic radiation of wave-length 2536, termed resonance radiation. If the density of the vapour is increased, the diffuse radiation (which is at first a volume radiation) is confined to a shallow layer of molecules lining the front surface of the bulb, and, with further increment of density, disappears entirely, being replaced by regular reflection, much as if the inner surface of the bulb was silvered. In the investigation here described an attempt has been made to clear up some of the doubtful points mentioned in previous papers, and to ascertain, if possible, how the diffuse scattering passes over into regular reflection. A water-cooled mercury arc of the type described by Kerschbaum was employed, and the quartz bulb was closed by a plate of slightly prismatic form. This latter arrangement allowed the rays reflected from the inner surface to be studied uncontaminated by the reflection from the outer surface. The experiments show that the scattered resonance radiation decreases, being replaced probably by true absorption, long before regular reflection commences. It also appears that the first appearance of specular reflection by the vapour takes place at a pressure not very far from 10 cm. Subsequent experiments showed that the dense vapour reflects polarised light in much the same way as a film of metal, but no effect could be detected analogous to the phenomena observed when light is reflected from a glass surface coated with metallic films of varying thickness, in which case the reflecting power is considerably diminished by very thin layers of metal. The specular or metallic reflection of the incident light by the vapour occurs only when there is exact synchronism between the luminous vibration and the free period of the system which causes the 2536 line.

The structure of the 2536 line was investigated, using a quartz Fabry and Perot interferometer, and the results obtained indicate that it is probably a doublet with a separation of about 0·03 Å.U. But a further study of the line with a higher resolving power will be necessary before a positive statement can be made. A. W.

1227. *Mechanical Equivalent of Light.* **H. E. Ives** and **E. F. Kingsbury.** (Phys. Rev. 8. pp. 254–258, Sept., 1916.)—The differences (20 to 30 %) in the values obtained by different experimenters for the mechanical equivalent of light [see Abs. 1435 (1915) and 322 (1916)] render it desirable to obtain an independent check by another method. A convenient way of doing this is to determine the radiant luminous efficiency of a chosen light-source, and compare this with the total luminous efficiency, thereby obtaining the efficiency losses due to conduction, convection, etc. These are then compared with the estimate of these losses obtained by independent means. Thus, if F is the luminous flux, P the applied power, R the radiant power, L_T the total luminous efficiency (obtained by multiplying the efficiency, in lumens per watt, by the mechanical equivalent of light), and L_R the radiant

luminous efficiency, then $R/P = (F/P)/(F/R) = L_T/L_R$. L_R is obtainable by measuring the radiation with and without the interposition of a "luminosity curve" template, it being understood that the luminosity curve employed is the one used to determine the mechanical equivalent.

This process was applied to a 32-c.p. oval anchored carbon filament lamp, the type for which Hyde has given the leading-in wire losses as from 4 to 5 % [see Abs. 415B (1911)]. To these are added convection losses, roughly measured by Drysdale as "not more than 2 or 3 %," and some additional loss (in the direction of measurement) due to the slightly different distribution of radiation by the heated glass bulb from that of the filament, which latter is all that comes into the "visible" measurement. This loss is taken as not more than 2 %. Altogether 9 % is taken as a not improbable value for the losses, giving 91 % as the radiation efficiency. This gives results in agreement with the authors' value of 0·00159 for the mechanical equivalent of light, whereas v. Pirani's value of 0·00123 corresponds to a radiation efficiency of only 71 %.

J. W. T. W.

1228. *Diffraction of a Rectangular Slit by a Spectrum Line of Finite Breadth.* **Y. Takahashi.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 499–508, July, 1916.)—It is well known that, in the Fraunhofer diffraction phenomena of a rectangular slit, the intensity of light in the image is given by the formula $\sin^2 u/u^2$ for a line source of light. But if a source has finite breadth, the expression for the intensity must be modified. It can be seen at once that the intensity curve in the image becomes flatter, the maxima and minima are displaced, and the minima do not vanish. As these facts have some significance in spectrum analysis, the intensity distribution was calculated for a source of light having a special distribution of intensity. The results and the method are given in the present paper. A. W.

1229. *On Light Extinction.* I and II. **C. W. Oseen.** (Phys. Zeits. 17. pp. 233–235, June 1, and pp. 341–343, Aug. 1, 1916.)—In the first article the author shows that if the electromagnetic theory of dispersion in Planck's form be assumed, Rayleigh's value for the extinction coefficient, namely $32\pi^3(\mu - 1)^2/3N\lambda^4$, is not obtained, but a value twice as great. This result is in contradiction with the actual facts and the author comes to the conclusion that the Maxwell-Lorentz electrodynamics is not able to afford an explanation of the actually observed extinctions. In the second article the author says he has since then recognised that this former belief of his was erroneous and that the contradiction is to be referred to an error in Planck's theory of dispersion. He then shows that Planck has correctly calculated the damping term of a resonator, but that the force acting on the resonator has not the value given by Planck; it contains an additional term which just cancels the damping term. The articles are highly mathematical. L. H. W.

1230. *Dispersion in Gases and Vapours.* **F. Reiche.** (Ann. d. Physik, 50. 1. pp. 1–52, June 6, and 2. pp. 121–162, June 15, 1916.)—An elaborate mathematical treatment of the subject, the chief points emerging being as follows:—

1. From the equations of motion of the electrons in a gaseous dispersive medium linear non-homogeneous equations are obtained which, by successive approximations, are solved in the form of a series. The first approximation is for the case of infinite rarefaction.

2. The summation of certain series depends on the solution of a linear non-homogeneous integral equation of the second kind with symmetrical core.

3. The solution of the integral equation gives at once the mean value of the electron displacements. From this the field at distant points is ascertained and compared with the corresponding formulæ for homogeneous bodies.

4. Then follows for the index of refraction of the gas the Drude-Voigt formula, which by the more exact calculation of the "exciting field" may be completed in the well-known way.

5. Questions as to the mean intensity and mean field are also discussed.

E. H. B.

1231. *Two-dimensional Dispersion Problem.* **C. Schaefer** and **H. Stallwitz.** (Ann. d. Physik, 50. 2. pp. 199–221, June 15, 1916.)—Mathematical discussion on the electromagnetic theory of diffraction at parallel cylinders of conducting material. [See Abs. 1129 (1910) and 1594 (1914).]

E. H. B.

1232. *Total Reflection and Poynting Vector.* (2) **A. Wiegrefe.** (Ann. d. Physik, 50. 3. pp. 277–280, June 29, 1916.)—Supplementary to an earlier paper of the author's [see Abs. 432 (1915)]. E. H. B.

1233. *Visibility at Total Reflection.* **H. Rose** and **A. Wiegrefe.** (Ann. d. Physik, 50. 3. pp. 281–282, June 29, 1916.)—Describes attempts at experimental verification of theories due to one of the authors. These have been interrupted by the war. [See preceding Abs.] E. H. B.

1234. *Optical Glass.* **W. Rosenhain.** (Soc. Arts, J. 64. pp. 649–658, Aug. 4; 663–672, Aug. 11, and pp. 677–687, Aug. 18, 1916. Engineering, 100. pp. 619–620, Dec. 17, 1915. Cantor Lecture.)—These lectures form a useful summary of the present state of knowledge of a subject regarding which little has been published. No brief abstract would be of value; the original pages should be consulted by those interested. Some remarks upon the possibilities of extending the range of available optical constants may, however, be quoted. The author thinks it probable that extreme optical properties are correlated with physical and chemical characteristics which tend so strongly to promote crystallisation that the retention of the material in the vitreous condition becomes impracticable. If this is the case we must look for optical media whose properties transcend those of glass among crystalline substances. The practice of optics has actually taken this step in at least one very important case, namely, the use of the mineral fluorite in the best microscope objectives. This mineral has a refractive index of 1·4338 and a ν value of 95·4, thus lying, in both respects, well outside the limits attainable in the case of glass. We have here a verification of the view that such extreme optical constants are only attained by crystalline material, and an examination of the optical constants of many other minerals at once confirms this view. Thus the garnets possess refractive indices ranging up to 1·81, while in some of the spinels this constant attains the very high value of 2·096.

The general conclusion would thus seem to be justified that for an extension of the range of available optical constants we must look to crystalline transparent minerals. Unfortunately there are very few minerals which can be satisfactorily employed for optical purposes. The great majority of these substances, as found in Nature, are more or less deeply coloured, and, moreover, their occurrence in large homogeneous and transparent pieces is rare. A further and fundamental limitation arises from the fact that the great

majority of minerals are doubly refracting to a more or less marked degree, and this property renders their use in general impracticable. Thus at the present time fluorite and rock crystal (quartz) are probably the only minerals employed in the shape of lenses, although calcite is used for Nicol prisms and rock-salt has been employed for special purposes.

The state of affairs just indicated, however, should not, in the author's opinion, deter us from the project of extending the range of our optical media by the utilisation of crystalline materials. A considerable number of minerals are known which are free from double refraction—*i.e.* those crystallising in the regular system, and the whole question resolves itself into the problem of obtaining crystals of these substances in sufficiently large sizes and of sufficient clearness and purity to be useful for optical purposes. The problem of the artificial production of crystals of the size and quality required, although offering many difficulties, would not appear to lie beyond the range of possible practical solution. With adequate resources used in the light of modern knowledge of the process of crystallisation, research on the question of the synthetic production of such crystalline material offers considerable promise of success. L. H. W.

1235. *Concave Lens-mirror used in the Suyehiro Optical Torsionmeter.* **K. Suyehiro.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 496–499, July, 1916.)—The object of the special mirror used in the author's torsion-meter is to obtain the image of the "pointing edge" sharp and fixed, using a large aperture. The present paper discusses the curvatures which must be given to the two surfaces so as to avoid spherical aberration to the extent of the second order. A. W.

1236. *Recent Improvements in the Petrographic Microscope.* **F. E. Wright.** (Washington Acad. Sci., J. 6. pp. 465–471, Aug. 19, 1916.)—Describes a sliding objective changer, also a device for use in the measurement of extinction angles, and deals with the removal of the astimagtism introduced by the analyser, as well as the prism method for the observation of interference figures. L. H. W.

1237. *Aperture of Eye-pupil.* **W. H. Stevenson.** (Brit. Astron. Assoc., J., June, 1916. Observatory, No. 504. p. 395, Sept., 1916. Abstract.)—The author has succeeded in taking instantaneous flashlight photographs of the eyes of five persons, in order to determine the aperture of the pupil in semi-darkness. The commonly accepted diameter of $\frac{1}{5}$ in. is found much too small, and probably refers to daylight aperture. The five subjects, of ages 21–25, gave values in good agreement, the average being $\frac{1}{3}$ in. This would indicate that the lowest useful magnifying power that can be employed with a telescope is about three times the aperture in inches. C. P. B.

1238. *Mechanism of Light-production in Animals.* **E. N. Harvey.** (Science, 44. pp. 208–209, Aug. 11, 1916.)—The author confirms the observations of Dubois (1884, 1887) that the luminous organs of the West Indian cucullo (*Pyrophorus noctilucus*) and of the luminous mollusc (*Pholas dactylus*) contain a thermostable substance, luciferin, which oxidises with production of light, and a thermolabile enzyme, luciferase. Similar results are obtained with the eastern American fire-flies, *Photinus* and *Photuris*, and with luminous bacteria. The luciferase of one organism will act with the luciferin of another. T. H. P.

1239. *Photochemical Sensitiveness and Photochemical Conductivity.* **M. Volmer.** (Zeits. Elektrochem. 21. pp. 113–117, April 1, 1915.)—Most theories of photochemical processes are based upon a connection between these and photoelectric effects, although Bodenstein, *e.g.*, is aware that the photochemical reaction is not accompanied by the splitting off of an electron from the sensitive substance. Photochemical rays do not ionise chlorine and oxygen (Lenard and Ramsauer, Ludlam), nor anthracene (Hughes, Pauli, Volmer), not even in solutions or vapours. But there is increase in the conductivity, especially in the region of the absorption bands, and this is not (as Pauli asserted) unconnected with fluorescence. The author tests the photoelectric conductivity of a large number of substances, silver haloids, sulphur, selenium, chlorine, mercury iodide, many organic substances. A film of the substance is produced (by sublimation or by evaporation) on one electrode, the wire-gauze electrode opposite being charged (160 to 320 volts). When the substance itself conducts fairly well (solid iodine, HgCl, HgS), the two electrodes are brought in contact; under insolation (mostly through cobalt glass) the current then rose to 10 and 25 times its value. In most cases the conductivity rose under light-excitation; negative effects were obtained with β-naphthol, benzoin, acridin; the experiments were inconclusive as to nitrobenzaldehyde and solid chlorine (at —100° C.). Ries and W. Wilson suggested that rays of long wave-length could liberate electrons like short waves. But the author altogether questions the real liberation of ions, because he does not see why an electron, once separated from its molecule, should rather travel through the solid than escape into the gas or vacuum, and he suggests that the electrons do not move freely, but progress by jumps from one molecule to another. The electrons are loosened, like the partially-separated valency electrons of J. Stark, and the conductivity mechanism would be similar to that assumed for the Grotthus theory of ionic conductivity. Photochemical sensitiveness and photoelectric conductivity are closely related to one another, and the photochemical reactions are due to a loosening of the electrons in Luther's sense. H. B

1240. *Absorption Spectra of Aniline Dyes and Gelatin Filters.* **A. Hnatek.** (Zeits. wiss. Photochem. 15. pp. 133–148, Oct. 15, 1915.)—In his gelatin filters for the separation of certain portions of a spectrum, the author defines the concentration of the colour by the dye-density number of Hübl which indicates the number of gm. of colouring matter uniformly distributed over one sq. metre of filter surface. The experiments were made with the Coudé spectrograph of the Vienna Observatory, and with sunlight and Wratten and Wainwright's panchromatic plates. Of the sixty odd aniline dyes examined not one gave absorption bands of sufficiently sharp definition to admit of wave-length determination; the edges on the red side were generally better defined than those on the violet side, but that distinction vanished in grating (instead of prism) spectra. Twenty-four of the dyes proved suitable for the preparation of gelatin filters. The filters are arranged in three groups, their ranges of absorption being about 1000 Å.U., 300 to 900, and 200 to 500 Å.U. By combination of several filters narrower ranges could sometimes be obtained, but the light was mostly too weak in such cases. H. B.

1241. *Short-wave Infra-red Spectra of Sulphates and Carbonates.* **C. Schaefer** and **M. Schubert.** (Ann. d. Physik, 50. 3. pp. 283–338, June 29, 1916.)—A long paper dealing with the selective reflection of solid sulphates and carbonates. Thirty of the former have been examined, including simple,

double, isotropic, and doubly refracting varieties. There are two well-marked maxima, one at 9 μ and the other at 16 μ. The latter has heretofore not been noted. These maxima are to be ascribed to the SO_4 ion. In the case of alums the maximum at 9 μ seems to be simple, whilst for uniaxial sulphates both maxima are double corresponding to the ordinary and the extraordinary rays. Biaxial sulphates exhibit triplicate maxima corresponding to the rays of the three indices of refraction.

Measurements of the spectra of fifteen carbonates showed that the CO_3-ion possesses three positions of selective reflection, at 6·5, 11·5, and 14·5 μ approx. In negative uniaxial crystals of the type of calcspar the maxima at 6·5 and 14·5 belong to the ordinary ray, that at 11·5 to the extraordinary ray.

Negative biaxial carbonates of the arragonite type have the maxima at 6·5 and 14·5 μ complex and derived from the rays of the largest and intermediate refractive indices, that at 11·5 from the axial ray possessing the smallest refractive index.

The results are discussed in the light of the space theories of Born, v. Laue, and Bragg, and it is concluded that there is a definite connection between ultra-violet and infra-red spectra.

"Water of crystallisation" presents an interesting phenomenon, and it is shown that the maxima for such water are shifted as compared with those of ordinary water. Moreover, in anisotropic crystals such "water" is itself anisotropic. [See next Abs.] C. S. G.

1242. *The Optical Behaviour of Water of Crystallisation.* **C. Schaefer** and **M. Schubert.** (Ann. d. Physik, 50. 3. pp. 339–345, June 29, 1916.)—A continuation of the investigations outlined in the preceding Abstract. Water of crystallisation is shown by examination of the corresponding reflection maxima in crystals of various hydrated sulphates to be uniaxial in uniaxial crystals and biaxial in biaxial crystals. The characteristic double reflection of crystals is reproduced in the "water of crystallisation," so that an identity of symmetry must be present.

The arrangement of the water within the crystals corresponding to di- or tri-chroism shows at once the space-lattice of the H_2O groups. C. S. G.

1243. *Accuracy in Measurement of Close Double Spectrum Lines.* **C. E. St. John** and **L. W. Ware.** (Mt. Wilson Solar Observatory, Contrib. No. 120. Astrophys. J. 44. pp. 15–38, July, 1916.)—Separations of specially selected double lines have been measured upon each of five series of spectrograms with dispersions varying from 1 mm. = 1·8 Å. to 1 m. = 0·23 Å. It is found that observations with the registering microphotometer enable incompletely separated components to be more reliably measured. Filar micrometer measurements of the separation between the components of close doublets vary with the width of slit, the precision of the focal settings, and the density of the spectrograms. Whatever decreases the intensity of the common region relatively to that of the continuous spectrum, produces a tendency on the part of the measurer towards increased separation, apparently by some effect of contrast. The differences between the Rowland and Mt. Wilson determinations of the separation of the components of close pairs of solar lines are systematic, and it is thought that these differences are errors in the Rowland values. C. P. B.

1244. *Changeable Lines in the Arc Spectrum of Iron.* **J. Lang.** (Zeits. wiss. Photochem. 15. pp. 223–228 and 229–252, Nov. and Dec., 1915. Disser-

tation, Bonn, 1914.)—Discrepancies between the determinations made by Fabry and Buisson and by Eversheim, and experiments made with long and with short arcs by Goos having thrown doubt on the constancy of the iron lines, the author studied the spectrum with short (2 to 4 mm.) and long arcs (9 to 16 mm.) and electrodes of iron, 8 to 10 mm. in diam., currents of from 3 to 15 amps. at pressures from 60 to 440 volts. The short arcs were horizontal, the long arcs would not keep steady unless vertical. The second-order spectrum was photographed on Schleussner or orthochromatic plates; the ranges studied were 5360 to 5660 Å.U. (same as Eversheim) and 2400 to 3300 (Goos). The wave-lengths of a large number of visible iron lines were found to vary somewhat with arc length, current, or slit position (near anode or kathode); there need not be real displacements, however, and the changes might be due to asymmetrical broadening; but that explanation and fluctuations in pressure would not account for the magnitude of the changes in some cases. The displacements in the ultra-violet were even more marked than in the green-yellow, and were sometimes to the red and sometimes in the other direction; the spectra from the anode and kathode hardly seemed to resemble one another occasionally. But there was a lack of sharpness in these ultra-violet lines, and reversals were frequent, especially near the negative pole at high current intensity, so that asymmetrical broadening might account for some, though not for all, of the phenomena. The author therefore picks out some lines as being unsuitable to serve as standards; as regards the green-yellow the selection of some other element in the place of iron would be advisable. H. B.

1245. *The Arc and the Spark Spectrum of Silver in International Standards.* **J. Frings.** (Zeits. wiss. Photochem. 15. pp. 165–183, Oct., 1915.)—With the aid of a concave Rowland grating of 8000 lines to the cm. and 6·5 m. radius of curvature the author determines, under Kayser, the arc lines of silver from 5667 to 3082, and the spark lines from 5471 to 2460 and also 2219 Å.U. With respect to the arc lines, the tables contain also the values of Kayser and Runge (Rowland), of Exner and Haschek, and of Kasper; as to spark lines, the lines of Exner and Haschek, of Wagner, and in the last group those of Eder and the author. The principal series is only found in the ultra-violet; two other series, $m = 4$ or 5, and 6 or 7, are distinguished. H. B.

1246. *Excitation of Helium Spectra.* **O. W. Richardson** and **C. B. Bazzoni.** (Nature, 98. p. 5, Sept. 7, 1916.)—In the course of an examination of the properties of the electron discharge in an atmosphere of helium, observations that seem to be of considerable interest were made of the conditions affecting the excitation of the lines of the helium spectra. The source of electrons was an incandescent tungsten filament, and the discharge passed to a parallel nickel wire about 8 mm. distant. The electrodes were mounted in a quartz tube filled with helium at a pressure of about 2 mm. In some experiments the helium spectrum was found to be excited at 22·5 volts p.d. If allowance is made for the initial kinetic energy of the electrons and for the drop of potential down the filament due to the heating current, this quantity is not increased by so much as one volt, and there are indications that it tends to approach a lower limit close to the ionisation potential value for helium found by Franck and Hertz and by Pawlow. In any event, the observations made would seem to destroy the special significance of the value (approximately 30 volts) of the minimum p.d. necessary to excite the line spectra of helium given by Rau. There is

no doubt that these spectra can be excited by the impact of electrons having energies much less than the value of the ionisation energy of helium calculated by Bohr. The authors are unable to reconcile these results with Bohr's theory except on the hypothesis that the impact ionisation of helium is a more complex phenomenon than has been supposed. Possibilities which suggest themselves are that the ionisation is the result of successive impacts, or results from impacts on atoms in an abnormal condition caused by the absorption of radiation generated in other atoms in consequence of electron impact. Experiments to test these possibilities are in preparation. In contrast to the lines of the mercury-arc spectrum the different helium lines behave differently *inter se* when the exciting voltage is changed. The order of excitation with voltage for the different lines is not simply a question of frequency, but depends partly on the series to which the lines belong. Most of the lines increase steadily in intensity with increasing voltage and current density, but the line 4713 of the second subsidiary series of helium increases rapidly to a maximum soon after excitation, then becomes very faint as the p.d. is increased to about 40 volts, reappears with higher voltages, and then increases steadily in intensity with rising potential difference. An examination was made of the extreme ultra-violet portion of the helium spectrum, using a photoelectric method, and definite indications were obtained of the presence of radiations having wave-lengths close to 600 and to 400 Å.U. respectively. A. W.

1247. *Stark-effect of the* 4686 *Spectrum Line.* **E. J. Evans** and **C. Croxson.** (Phil. Mag. 32. pp. 327–329, Sept., 1916.)—Describes experiments carried out on the 4686 line by Lo Surdo's method. Field strengths up to about 37,000 volts per cm. were employed. With this field the 4686 line showed a definite broadening in the dark space, but no definite components could be identified. The line in the strongest photographs appeared to be broadened nearly symmetrically, and the intensity of the outside edges was less than the middle portion of the line. The total width of the line in the dark space was 3·7 Å.U., and the corresponding distance between the components of H_β was 7·2 Å.U. Each of the components of H_β was double, but the lines were too diffuse for an accurate estimate of the distance between the outside components. However, by making use of Stark's results, it could be calculated that this distance was approximately 10 Å.U. For the sake of comparison the widths of the 4686 and H_β lines were measured in the region above the dark space and found to be in each case about 1·4 Å.U. Although it is impossible from these results to test quantitatively the simple theory of the Stark-effect for the 4686 spectrum line, it seems evident that if the broadening of the line is altogether due to the electric field, its magnitude is decidedly less than one-half that of H_β. It also follows that it is difficult to explain by means of the Stark-effect the great width of the line in comparison with the hydrogen lines when they are generated by a condenser discharge. Further experiments will be undertaken, either with a spectroscope of higher power, or with stronger electric fields. [See Abs. 1437 (1915) and 564 (1916).] A. W.

1248. *Mica X-ray Spectrometer.* **M. Siegbahn.** (Phys. Rev. 8. pp. 320–322, Sept., 1916.)—W. S. Gorton, using the mica X-ray spectrometer, has published a series of results on the tungsten spectrum [see Abs. 684 (1916)]. Reviewing these results the author concludes that they are based on false assumptions. By a graphical method Gorton has measured a great many lines in the tungsten spectrum for which he claims an accuracy of 0·5 %. The

author now attempts to prove that there are in reality—in the domain of small angles—much greater errors, which may lie in the inaccurate method. From his measurements Gorton concludes that mica has four reflecting sets of planes parallel to the cleavage face. The distances of two of these give no simple relations. In his opinion they indicate "a substance which is mixed in with the mica and scattered non-uniformly through it." The author suggests that the results obtained are due to Gorton ascribing all lines to a first-order spectrum, whereas he considers they really belong to the second, third, fourth, and fifth orders. The first-order lines are missing—perhaps because they are covered by the central blackening. A. B. W.

1249. *Law of Absorption of X-rays at High Frequencies.* **A. W. Hull and M. Rice.** (Phys. Rev. 8. pp. 326–328, Sept., 1916. Paper read before the Am. Phys. Soc.)—It has been shown, from Barkla's absorption data and Moseley's table of wave-lengths, that the coefficient of absorption of all metals varies approximately as the cube of the wave-length, except in the immediate vicinity of one of the characteristic wave-lengths of the metal. The experimental data extend over a range of wave-lengths from 4 to 0·5 Å.U. approximately, but the law has frequently been extrapolated to very short wave-lengths and used as a measure of wave-length. The measurements described in the present paper were made to examine how far such extrapolation is justified. The results are included in the following table :—

Wave-length.	Mass Absorption Coefficient.					
	Al		Cu		Pb	
Ångstroms.	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.
0·392	0·860	1·02	—	—	—	—
0·343	0·726	1·721	—	—	—	—
0·294	0·493	0·499	3·84	3·94	11·1	11·04
0·245	0·342	0·339	2·24	2·33	6·7	6·44
0·221	0·283	0·281	1·70	1·74	4·63	4·76
0·208	0·255	0·254	1·39	1·47	3·70	3·99
0·196	0·243	0·232	1·27	1·25	3·40	3·36
0·184	0·218	0·213	1·07	1·06	2·71	2·80
0·172	0·199	0·196	0·91	0·88	2·32	2·31
0·160	0·178	0·181	0·79	0·74	1·82	1·88
0·147	0·154	0·167	0·71	0·60	1·50	—
—	—	—	—	—	2·80	—
0·122	—	—	—	—	3·00	—

A. B. W.

RADIO-ACTIVITY.

1250. *Density of Radio-lead from Norwegian Cleveite.* **T. W. Richards and C. Wadsworth.** (Am. Chem. Soc., J. 38. pp. 1658–1660, Sept., 1916.)—A brief description is given of the determination of the density of lead from a particularly pure specimen of Norwegian cleveite. The lead separated out from the mineral, and presumably a pure isotope, was found to have a density 11·273, decidedly lower than that from a sample of Australian radio-lead previously studied (11·289), and still lower than the density 11·337 found for ordinary lead. The corresponding atomic volume of the pure isotope is essentially equal to that of ordinary lead, as indicated by earlier results on Australian radio-lead. A. B. W.

HEAT.

1251. *Thermal Conductivity and Viscosity of Gases and Molecular Complexity.* **J. A. Pollock.** (Roy. Soc. New South Wales, J. 49. pp. 249–252, 1915.)—In the equation : thermal conductivity $K = f\eta c_v$ (η = viscosity), f is a numerical factor which is approximately constant for gases of the same atomicity. There should hence be a relation between f and $\gamma = c_p/c_v$. Long before that equation was established, Boltzmann suggested $f = 3f'(\gamma - 1)/2$ where f' is a constant for monatomic gases. Eucken determined (1913) the thermal conductivities of a large number of gases (elements and compounds) and discussed the relation between f and temperature and properties of the molecule, without referring to γ, however. From Eucken's values for K and η (for zero temperature) the author deduces $f = a(\gamma - 1)/\gamma^n$, where a seems to be 7·32 and $n = 1·3$. For many years the values of f for diatomic gases was supposed to be 1·6029 ; Eucken's value is 1·9. H. B.

1252. *Black-body Brightness Equations.* **H. E. Ives** and **E. F. Kingsbury.** (Phys. Rev. 8. pp. 323–325, Sept., 1916.)—Foote and Fairchild have developed equations for the luminous flux emitted by the black body by considering the flux a function of the equivalent wave-length [see Abs. 702 (1916)]. In this paper are calculated the values of the constants to be used in their form of equation in order that it may represent the spectral luminosity curve obtained by the authors [Abs. 62 and 556 (1916)]. The resulting expression for the luminous flux at any temperature is $L = 23·934\ [(T - 55·853)/(T + 197·138)]^{104·221}$ which gives the light watts per steradian per unit solid angle with very great accuracy (within ½ %). From this the candle-power per cm.² may be derived by dividing by the mechanical equivalent of light. A still simpler working formula is $L = 24000\ e^{-1/n}$, where $n = 0·00003795\ T + 0·00250$. This is correct to about ½ % over the range from 1200° to 3000°. J. W. T. W.

1253. *Compton's Formula for the Temperature Variation of the Specific Heat of Solids.* **F. Schwers.** (Phys. Rev. 8. pp. 117–127, Aug. 1916.)—A comparison of the results given by Compton's formula [Abs. 83 (1916)] and Debye's formula [Abs. 446 (1913)] for the variation in the specific heats of solids at very low temperatures is altogether in favour of the latter formula. The results are tabulated in the case of the specific heats of Cu, Al, Pb, calcium fluoride, and iron pyrites. T. S. P.

1254. *Determination of the Mechanical Equivalent of Heat by Hirn's Method.* **L. Hartmann.** (Comptes Rendus, 163. pp. 222–224, Aug. 28, 1916.)—In the case of the impact of two masses, m and m', of which one has the velocity v, and the other is at rest, theory leads to the values of the resulting velocities, ϕ and ϕ', namely $\phi = (1 - N)\,v$, and $\phi' = Nv\,(m/m')$, ... (1), N being equal to $2m'/(m + m')$.

Experiments with steel cylinders of 12 mm. diam. with spherical ends, the radii of the spheres being equal to the length of the cylinder, gave results which did not agree with the theoretical formulæ. The experimental velocities after the blow being ψ and ψ' (these being varied between wide limits), it was found that $\psi = (1 - n)\,v$, and $\psi' = nv\,(m/m')v$, the equations thus being similar in form to equations (1). The value of "n," however, was not constant, but progressively decreased in value as "v" increased. In

other words, instead of the usual equation of energy $mv^2 = m\phi^2 + m'\phi'^2$, we have $m\psi^2 + m'\psi'^2 = mv^2\,[1 - 2n\,(N - n)/N]$. It is thus concluded that experiment does not confirm the hypothesis that the difference of the kinetic energy before and after the impact, and the heat given out by the crushing of the lead are equivalent. T. B.

1255. *Critical Points of Nitrogen, Carbon Monoxide, Oxygen, Methane.* **E. Cardoso.** (Journ. Chim. Phys. 13. pp. 312–350, Nov. 15, 1915.)—All these gases are difficult to liquefy; the method has previously been explained (Ibid. p. 470, 1912). The apparatus is an improvement of that of Ramsay and Young; the cryostat is described in detail. Within a Dewar vessel, not silvered, containing liquid air, is mounted a double-walled recipient (35 cm. high, 2·3 and 2·9 cm. diam.) charged with a liquid serving as cold bath; the space between the two walls is charged with gaseous hydrogen under adjustable pressure; the liquid is stirred by blowing air through it. The temperature of the bath can be kept constant within $\pm 0{\cdot}05$ deg. between $-80°$ and $-160°$, but the strain on the experimenter is severe. The pentane first tried as bath liquid froze at -110 or $-120°$. After many trials the author took petrol ether, treating it for three days with potassium permanganate, constantly renewed; the resulting liquid smelt of isopentane and froze at $-160°$. Gas thermometers, liquid (Baudin) and Pt-resistance thermometers proved unsuitable for long-continued working at low temperatures; isopentane thermometers were finally adopted. The results of the determinations of the critical temperatures and critical pressures are: N_2, $-144{\cdot}70°$, 33·65 atmos.; CO, $-138{\cdot}7°$, 34·60 atmos.; O_2, $-118{\cdot}0°$, 49·30 atmos.; CH_4, $-82{\cdot}55°$, 45·60 atmos.; these figures are probably correct within $\pm 0{\cdot}1$ deg. and $\pm 0{\cdot}1$ atmo. Much greater accuracies are hardly possible, and the author critcises the exaggerated accuracy claims frequently made. The critical density of CO is found to be 0·3110, that of methane 0·1623; these are possibly correct within $\pm 1/600$; the series of observations were in excellent agreement. H. B.

1256. *Berthelot's Equation of State applied to Vapours.* **H. Schimank.** (Phys. Zeits. 17. pp. 393–396, Sept. 1, 1916.)—In his book on "Thermomètres à Gaz" D. Berthelot gave in 1903 the formula—

$$pv = RT[1 + \frac{9p_0\delta_0}{128\pi_0 T}(1 - 6\delta_0 T^2)],$$

in which π_0 and δ_0 are the critical pressure and temperature of the gas. The author tests this formula with respect to the behaviour of saturated or nearly saturated vapours, which strongly deviate from the gas laws, at moderate pressures, and he further compares the results with those of the Nernst formula. He takes his data from the vapour density determinations of Ramsay and Steele for ether, benzene, toluene, hydrocarbons [see Abs. 889 (1904)], from the vapour densities of hydrogen of K. Onnes and W. J. de Haas at temperatures 20·5° to 15·8° abs., and, modifying the formula, from the heats of evaporation of argon, nitrogen, oxygen, carbon disulphide, alcohol, benzene, etc., according to various experimenters. The conclusion is that the formula of Berthelot fails in the extreme case of hydrogen, but agrees in all the other cases better with the experimental data than the formula of Nernst (under whom this investigation was made). The Berthelot formula would thus in general be recommendable, but the quotient 9/128 should probably be regarded as a function of the temperature, and not as a constant. H. B.

1257. *Vapour Pressures of Binary Liquid Mixtures.* **F. Tinker.** (Phil. Mag. 32. pp. 295–302, Sept., 1916.)—Dieterici's modification of van der Waals' equation of state [see Abs. 1183 (1911)] is applied to the calculation of the total vapour pressure of a mixture of two liquids, and the expression deduced is found to be of the same form as that obtained by van Laar by means of the thermodynamic potential. By expanding the exponential terms in the equation and approximating it is shown that, provided that the changes of volume on mixing are small, the total vapour pressure of a binary mixture is equal to that calculated from the law of admixture in molecular proportions multiplied by a factor $(1 - \delta L/RT)$, where δL is the excess of the molecular latent heat of vaporisation of the mixture over the theoretical value calculated by the mixture rule. No measurements are yet available to test the equation, but it is confirmed indirectly from surface-tension data. Experiment shows that latent heat of vaporisation and surface tension are proportional to one another, and it is known that the surface tension and vapour pressure of binary mixtures are related in the manner indicated by the author's formula for latent heat and vapour pressure. D. O. W.

1258. *Absorption of Black Radiation in the Water-vapour and CO_2 of the Air.* **W. Gerlach.** (Ann. d. Physik, 50. 3. pp. 233–244, June 29, 1916.)—Although many experimenters have observed that even a small amount of CO_2 gives a notable amount of absorption, especially in the infra-red rays, no exact measurements have been made with well-defined sources of radiation. This type of measurement is, however, very important, as water-vapour and CO_2 are always present in atmospheric air. Paschen found, for example, that a thickness of 7 cm. of CO_2 was sufficient to absorb practically all the infra-red radiation. Experiments have been carried out with the object of determining exactly the influence of water-vapour and of CO_2 on the total black radiation, the source consisting of the central part only of a piece of heated Pt-foil, covered with platinum black, as was also the receiver, as in the Lummer-Kurlbaum experiments. The distance between radiator and receiver was 33 cm., the space being completely closed in. Careful measurements were made of the absorption in pure air, in air containing CO_2, and in air containing CO_2 and water-vapour, at temperatures from 300° to 700° abs. It was found that absorption by water-vapour is only shown at the higher temperatures, and is, in general, proportional to the amount of water-vapour actually present. Absorption by CO_2 comes into prominence at temperatures about 500° abs., and has its max. influence between 600° and 700° abs. T. B.

1259. *Use of Lampblack and Platinum Black on the Receiver in Absolute Radiation Measurements.* **W. Gerlach.** (Ann. d. Physik, 50. 3. pp. 245–258, June 29, 1916.)—Attention is drawn to the unsatisfactory results that may be obtained when the receiver in measurements of radiation is blackened by means of lampblack. This is especially the case when low pressures are employed, as is shown in some results given by Westphal [Abs. 460 (1913), 289 (1914)], who worked at pressures of about 1 mm. The absolute values of the radiation measured with an absolute bolometer do not depend either on the gas or the pressure when an electrically deposited platinum black is employed, but in the case of lampblack this is not the case. As the pressure is decreased from atmospheric pressure there is constancy down to about 200 mm., then a slow, followed by a steep fall in the radiation, with a minimum between 0·6 and 0·1 mm., and finally a rise, until at the lowest attainable pressure the results are again about equal to those at atmospheric

pressure. The thickness of the lampblack layer also has a decided influence on the results. Again, if the lampblacked plate is heated by electrical energy, the results do not agree with those obtained from heating by radiation. In order, therefore, to obtain consistent results, platinum black should be employed in work of this nature. T. B.

1260. *The Constants of the Stefan-Boltzmann Radiation Law; New Absolute Measurements between* 20° *and* 450° *C.* **W. Gerlach.** (Ann. d. Physik, 50. 3. 259–269, June 29, 1916.)—A continuation of earlier work [see Abs. 1229 (1912)], a similar method being employed, but with a completely new arrangement of apparatus. The receiver was covered with platinum black, and corrections were applied for the presence of water-vapour and CO_2 [see two preceding Abstracts]. The mean value of the constant σ, as given by 52 independent observations, was $5{\cdot}85 \times 10^{-12}$ watt cm.$^{-2}$ deg.$^{-4}$ at temperatures 20° to 450° C., this being in good agreement with the results of the former paper for temperatures 0° to 100° C., where $\sigma = 5{\cdot}9 \times 10^{-12}$. An exact knowledge of this constant gives a means of testing the Planck radiation formula. According to Millikan's new photoelectric measurements, assuming $e = 4{\cdot}77 \times 10^{-10}$ e.s. unit, the value of the "universal constant" h is $6{\cdot}58 \times 10^{-27}$ erg sec. From Planck's formula, $h = ac_2^4/48\pi ac$, if $h = 6{\cdot}58 \times 10^{-27}$, $a = 4\sigma/c = 7{\cdot}80 \times 10^{-15}$ erg cm.$^{-3}$ deg.$^{-4}$, and $\sigma = 5{\cdot}85 \times 10^{-12}$ watt cm.$^{-2}$ deg.$^{-4}$, it follows that $c_2 = 1{\cdot}4250$. The latest measurements at the Reichsanstalt by Warburg and Müller give $c_2 = 1{\cdot}4250$, $1{\cdot}4300$, and $1{\cdot}4400$, the lowest value being obtained from the use of the Stefan-Boltzmann law. Applying this value of c_2 in Planck's equation, the value of e is $4{\cdot}83 \times 10^{-10}$ e.s. unit. According to Millikan the best experimental value of e is $4{\cdot}77 \times 10^{-10}$. Finally, for the Loschmidt number, N, the value obtained (if c_2 is taken as $1{\cdot}425$) is $N = 60{\cdot}0 \times 10^{22}$, and (for $c_2 = 1{\cdot}430$), $N = 59{\cdot}3 \times 10^{22}$. The value of N recently given by Nordlund, from direct measurement, is $59{\cdot}1 \times 10^{22}$.

T. B.

1261. *Constants of Spectral Radiation of a Uniformly Heated Enclosure or so-called Black Body.* II. **W. W. Coblentz.** (Bureau of Standards, Bull. 13. 459–477, 1916 [Sci. Papers, No. 284].)—In a previous communication the results of an investigation of the constant of spectral radiation of a black body were presented [Abs. 901 (1914)]. The position, λ_m, of the maximum emission E_m, was computed by taking the wave-lengths λ_1 and λ_2 corresponding to equal intensities $E\lambda_1 = E\lambda_2$, on the assumption that the observed energy curve fits the Planck equation. The equation used in computing λ_m requires a knowledge of the constant C, and the value taken was C = 14,500. A new, and apparently more reliable calibration curve of the fluorite prism used in the work, and the discovery of small errors all acting in the same direction have necessitated a recomputation of the values of the constants. These are now given as C = 14,369 (the mean data of other investigators giving 14,350) micron degrees; A = 2890 micron degrees; the coefficient of total radiation, $a = 5{\cdot}7 \times 10^{-12}$ watt cm.$^{-2}$ deg.$^{-4}$; and the constant, h, of the quantum theory, of the order $h = 6{\cdot}56$ to $6{\cdot}57 \times 10^{-27}$ erg sec.

In an appendix a note is given on methods of calculating the spectral radiation constants. It is found that the spectral energy curves obtained fit very accurately the Planck equation, but not the Wien equation. Diagrams are given supporting this statement. T. B.

SOUND.

1262. *Acoustic Repulsion of Jets of Gas.* **A. T. Jones.** (Dissertation [50 pp., 1916], Clark Univ., Worcester, Mass.)—The author has examined the conditions under which a flame is deflected by progressive waves of sound. The principal results are as follows:—(1) The deflection is usually in the direction of advance of the waves. (2) It is not caused by any mean streaming of the air. (3) It is probably caused in part by the recognised pressure of sound on the hot gases of the flame. There may be also some other cause not yet discovered. (4) In one striking case the flame was cylindrical in its undisturbed portion below the track of the sound-waves, but where the waves impinged it became flattened and was repelled, the edges of this blade-shaped flame being more repelled than its centre. (5) Another special case was the attraction of a flame of illuminating gas from a Bunsen burner with the air inlet closed. In this case and many others the source of sound was a telephone receiver.

The paper includes a number of diagrams and tables, a theoretical examination of the phenomena, and a plate of over a score of photographic reproductions of the deflected flames. E. H. B.

1263. *Acoustics of Auditorium at Illinois.* **F. R. Watson** and **J. M. White.** (Univ. of Illinois, Bull. No. 87. [20 pp.], May, 1916. Engineering, 102. pp. 380–382, Oct. 20, 1916. Abstract.)—The acoustics of the auditorium of the University of Illinois was originally very faulty, having echoes and a prolonged reverberation. This was cured by the author as described in a previous paper [see Abs. 1564 (1914)]. The present paper describes the changes introduced in the absorbing material so as to conform more exactly to the curvature of the walls and lend itself to the new scheme of decoration. At the same time a pipe organ was installed and a change made in the lighting system. The new absorbent was hair-felt in vertical strips and then covered with rep which was suitably decorated where desired.

Plans, sections, and perspective views of the interior are shown at various stages of the work. The result is satisfactory both for music and speaking. For orchestral music it is found advantageous to have the wooden floor of the stage bare of carpet in order to reinforce the sound from the instruments.

E. H. B.

1264. *Gun-firing and Silence Zones.* **E. Esclangon.** (Comptes Rendus, 163. pp. 167–169, Aug. 14, 1916.)—The author divides the sounds heard into three classes: A, those from the abrupt expansion of gases at the muzzle, or report proper; B, the sounds arising from the aerial wake of a projectile at a speed exceeding that of sound; C, the explosions of projectiles. Near the front the three sets are all evidently perceived. Sounds in Classes A and C are habitually heard at 30 km. distance, but those of Class B may be heard at 50, 100, and even 200 km. It is pointed out that the source of these sounds is spread over a considerable length of the trajectory. E. H. B.

1265. *Propagation of Sound in the Free Atmosphere.* **W. Schmidt.** (Phys. Zeits. 17. pp. 333–335, Aug. 1, 1916.)—A general *résumé* of the chief observational data and theories concerning them as to the propagation of intense sounds on the large scale and the zones of silence sometimes found to occur, succeeded by second audible regions. [See Abs. 708, 1055 (1916).] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1266. *E.M.F. produced by Acceleration of Metals.* **R. C. Tolman** and **T. D. Stewart.** (Phys. Rev. 8. pp. 97–116, Aug., 1916.)—The modern theories of electricity have led to the belief that the passage of an electric current through a metal really consists in the progressive motion of "free" electrons contained in the body of the metal itself. If this be true we may now expect a number of effects arising from the *mass* of these electrons which were not predictable on the basis of older theories in which electricity was regarded as a sort of intangible, massless fluid. As examples of such effects, we might expect the rear end of an *accelerated* rod of metal to become negatively charged owing to the lagging behind of the relatively mobile electrons which the metal contains, and should expect the periphery of a rotating disc to become negatively charged owing to centrifugal action on the electrons in the disc.

It was in this latter way that an effect was experimentally sought. The galvanometer throw obtained was *always* in the direction predicted on the basis of mobile electrons with a negative charge. On the theory developed the quantitative agreement of the experiments is in fair accord with the mass of an electron in free space. [See also Abs. 1089 (1914).] E. H. B.

1267. *Value of "h" Determined Photoelectrically from the Ordinary Metals.* **W. H. Kadesch** and **A. E. Hennings.** (Phys. Rev. 8. pp. 221–226, Sept., 1916.)—Further to the work described in a previous paper additional experiments have now been carried out on Mg and Al. It is concluded that the value of h is in accord with that required by Einstein's photoelectric equation. [See also Abs. 363 (1916).] E. H. B.

1268. *Some Determinations of the Sign and Magnitude of Electric Discharges in Lightning-flashes.* **C. T. R. Wilson.** (Roy. Soc., Proc. 92. pp. 555–574, Sept. 1, 1916.)—The method consists in determining at a fixed station the change in the vertical electric force near the ground which occurs as a result of a lightning-flash, of which the distance from the station is known. The earth being treated as a plane conductor, the vertical force at a point on the surface due to a charge on a thundercloud and the induced charge on the earth is $-2qh/r^3$, where h is the height of the cloud, q the charge, and r the distance of the cloud from the point on the surface. When a lightning-flash passes between the earth and the cloud, the charge on the cloud and the corresponding induced charge on the earth are destroyed, and the vertical force due to them disappears. Thus $2qh/r^3$ or $2M/r^3$ is the change (F) in the vertical force due to the flash, where M is the electric moment (qh) of the discharge. Thus $F = 2M/[d^3(1 + h^2/d^2)^{3/2}]$ where d is the distance to the ground end of the discharge. Putting $Fd^3 = 2M'$, we have $2M' = Fd^3 = 2M/(1 + h^2/d^2)^{3/2}$.

An apparatus is described by means of which the surface density of the charge on the ground can be measured, and also any sudden change in the surface density, as produced by lightning. The vertical force is proportional to the surface density. The apparatus is essentially a self-record-

ing form of the Wilson portable electrometer which forms part of the equipment of most physical observatories, but it is constructed on a much larger scale, and the surface of the "test-plate" is made to resemble the undisturbed surface of the ground, with which it is in the same plane. The test-plate is about 50 cm. in diam., and the dimensions of the remainder of the apparatus are arranged on a similar scale. The method of observation is to watch the electrometer of the instrument for sudden movements due to lightning, and to note the interval between each movement and the first sound of the succeeding thunder. This interval gives a measure of d assuming the discharge to be vertical, while F is obtained from the motion of the electrometer index. Thus M′ can be found, and corresponding values of M′ and d can be plotted on squared paper for successive discharges of a storm. The points so obtained usually lie approximately on a hypothetical curve obtained on the assumption that both q and h, and therefore M, remain constant throughout the storm. Values of h are assumed in different cases varying from 8 to 15 km. and q is of the order of 30 coulombs (10^{11} electrostatic units). By supposing that the discharge takes place between two layers of cloud instead of between a cloud and the earth, and suitably modifying the theory, different values for heights of the clouds combined with charges of the order of 30 coulombs are found to give curves which will also fit the observations very well. Thus while the heights of the clouds remain doubtful, the author considers that 30 coulombs is a fair measure of the amount of electricity involved in each flash.

The fullest observations were made in storms of which the prevailing direction of the displacement currents due to the discharges was upwards, but that is not always the case in a thunderstorm. Even if the direction of the current were always upward, on the assumption that the quantity of electricity in each discharge is 30 coulombs, about 30 lightning-flashes every second would be required to neutralise the total conduction air-earth current due to the normal atmospheric potential gradient. R. C.

DISCHARGE AND OSCILLATIONS.

1269. *Photo-potentials due to Light of Different Frequencies.* **A. E. Hennings** and **W. H. Kadesch.** (Phys. Rev. 8. pp. 209–220, Sept., 1916.)—Examines the properties of a number of metals (Mg, Al, Zn, Fe, Sn, Cu) in respect of the max. energies of photo-electrons emitted under the influence of light derived from a mercury arc in quartz. The energies were determined by noting the retarding potentials sufficient to stop the photoelectric discharge. The photo-current-potential curves were all found to plunge sharply into the potential axis. This indicates that photo-electrons released from a given surface under the influence of light of a given frequency have energies which do not exceed a definite finite value. The apparent max. positive potentials assumed by the six metals were the same so long as the surfaces had been newly scraped in a vacuum. This corroborates the theory advanced by Millikan [see Abs. 362, 375 (1916)], which is also supported by the results of Richardson and Compton, Hughes, and Kadesch. This theory makes the contact p.d. $= h(\nu_0' - \nu_0'')/e$, where ν_0' and ν_0'' are the critical oscillation frequencies at which electrons cease to be emitted. The emission energy decreases with age, probably owing to the formation of retarding films. E. E. F.

1270. *Influence of Occluded Gases on the Photoelectric Effect.* **R. J. Piersol.** (Phys. Rev. 8. pp. 238–247, Sept,, 1916.)—Experiments on Pd, Pt, Au, Ni, and Ag in the form of strips heated several times electrically *in vacuo* show that a photoelectric effect exists which is due entirely to an intrinsic property of the metal. Superimposed upon this effect there is a max. effect due to occluded gases, chiefly dependent upon the amount of gas driven from the interior to the surface by the heating. In metals of high fusing-point a sufficient number of heatings drive off the occluded gases to such an extent that all abnormal effects disappear. The photoelectric sensitiveness after the emission of occluded gases is larger than the effect noted before the expulsion of the gas. E. E. F.

1271. *Photoelectric Effect in Lithium, Sodium, and Potassium.* **W. H. Souder.** (Phys. Rev. 8. pp. 310–319, Sept., 1916.)—Investigates the photocurrent per unit of incident energy as a function of the wave-length, using normal incidence on new surfaces of K, Na, and Li formed by shaving *in vacuo*. The energy was measured by a 10-element thermopile connected with a sensitive moving-needle galvanometer. The only source of energy free from stray effects when used with a Hilger monochromatic illuminator was found to be a mercury arc, which was run at a temperature approaching the melting-point of quartz, and required special precautions against physiological effects. Curves of photo-current per energy are plotted against wavelengths. The maxima are about 382 $\mu\mu$ for K, 350 $\mu\mu$ for Na, and 260 $\mu\mu$ for Li. The shape of the curves suggests a "selective" effect under conditions which ordinarily would only give Pohl and Pringsheim's "normal" effect. This may have something to do with the fact that the surfaces studied were prepared by cutting with a razor-edge tool, thus giving a mirror-like surface. E. E. F.

1272. *Effect of a Magnetic Field on the Conductivity of Flames.* **C. W. Heaps.** (Phys. Rev. 7. pp. 663–675, June, 1916.)—In the experiments described the velocities of the negative flame ions have been determined for different values of the electric intensity. To avoid complications the electric current was made to flow vertically in the same direction as the flame gases and the upper electrode, the kathode, was coated with metallic oxides to eliminate the kathode fall of potential. The potential gradient through the flame (measured by exploring wires connected to an electrometer) was studied in a series of cases and conductivities in different parts of the flame were thus determined, both with and without an applied transverse magnetic field. With weak electric fields the conductivity is higher in the lower part of the flame; for stronger fields, the variation is smaller and the conductivity is higher in the upper part. When a transverse magnetic field is applied the variation of conductivity is made greater. A large drop of potential near the anode was observed with big p.d.'s between the electrodes, which became much smaller for smaller applied potentials.

The current-voltage curve resembles a "saturation curve." This is not a true saturation curve, but is explained as mainly due to the appearance of the anode fall of potential, the final rise of the curve being due to ionisation by collision. It is shown that $U = (X/H)\sqrt{[(I - I)/I_H]}$, where U is the velocity of the ion under electric intensity X and I, I_H are the currents through the flame without and with the transverse magnetic field H. Hence by measuring the effect of the magnetic field on the conductivity of the flame the velocity of the negative ions can be determined. The velocity, k, of the ion under unit

potential gradient was found to have a max. value of 20,400 cm./sec. It is shown that k varies with x/p, when p is the gas pressure, in much the same way as Townsend has shown k to vary for air at ordinary temperatures: for small values of x/p the velocity is proportional to x/p, a stage is reached when the velocity increases rapidly with x/p, and for larger values of x/p it becomes again nearly proportional. The conclusion is drawn that when x/p is above 0·09 the flame ions are free electrons; with x/p between 0·09 and 0·01 the electrons begin to associate with gas molecules, and when x/p is below 0·01 the electrons are free for about one-eighth of the time. This variation of k with x/p probably explains the lack of agreement between the values of k as determined by different experimenters. T. H.

1273. *Retrograde Rays from the Cold Kathode.* **O. H. Smith.** (Phys. Rev. 7. pp. 625–632, June, 1916.)—This is a study of the retrograde rays in residual air, a much finer beam than that used by J. J. Thomson being used [Abs. 1890 (1907)]. Photographs were obtained in the usual way after deflection of the rays by electrostatic and magnetic fields. The molecule of hydrogen appeared on every plate, accompanied by a heavier carrier which was usually the molecule of oxygen. The presence of helium apparently made no difference.

It was found that the lines due to the negative ions in the rays on the photographic plates were clearer and sharper than those due to the positive, which, it is suggested, is due to the disturbance to the path of the positive particles in the process of losing electrons and becoming positive. The lines were distinct enough to admit of determining approximately the place where the slowest ions strike, *i.e.* those that had just sufficient velocity to affect the plate. The measurements showed that the power to affect the plate is a function of the kinetic energy of the particle. The minimum energy required is of the order $7{\cdot}4 \times 10^{-9}$ erg, but this value appears to depend somewhat upon the emulsion of the plate. T. H.

1274. *Low-potential Discharge Spectrum of Mercury Vapour in Relation to Ionisation Potentials.* **J. T. Tate.** (Phys. Rev. 7. pp. 686–687, June, 1916. Abs. of paper read before the Am. Phys. Soc., April, 1916.)—Franck and Hertz have shown that collisions between electrons accelerated in an electric field and atoms of mercury vapour, are elastic for velocities of the electrons less than 4·9 volts. At this velocity the electrons are capable of giving up all their energy at collision. They also showed that part, at least, of this energy was emitted by the vapour as monochromatic radiation of wave-length 253·67 $\mu\mu$, the frequency to be expected if $h\nu = eV$. The author has repeated the measurements of Franck and Hertz very carefully, and has obtained a value of $4{\cdot}90 \pm {\cdot}03$ volts for the critical velocity. Indications of secondary maxima in the current-potential curves were found showing the possibility of other types of collision at higher potentials. A secondary critical velocity of the electrons is to be expected at which the energy they give up is emitted as radiation of many frequencies corresponding to the many-lined spectrum of mercury. The present paper deals with an attempt to fix the value of this secondary critical velocity and to demonstrate whether or not ionisation takes place at this point. The apparatus used consisted of a discharge tube into which a mercury barometer column projected, giving a continuous supply of mercury vapour when heated by a hot kathode situated about 2 cm. above the surface of the mercury. A Pt net screening the mercury surface served as anode. To further concentrate the field a second Pt net was introduced

between the hot kathode and the anode. The space between the nets was focused on the slit of a quartz spectrograph in such a way that the lines of the spectrum were limited in length by the nets. The initial velocity of the electrons was obtained in the usual way. It was found that with velocities corresponding to total effective potentials of more than about 5 volts and less than 10 volts the spectrum consisted of a single line of wave-length 253·67 $\mu\mu$. At about 10·3 volts the many-lined spectrum of mercury began to appear in the region of the anode, and with increasing potentials the lines gradually increased in length. Current-potential curves showed a very sharp break at 10·0 volts, but no break was detected in the region of 4·9 volts. Thus a marked ionisation occurs in mercury vapour when the velocity of the colliding electrons reaches a critical value of 10 volts, which is very nearly the value (10·2 volts) to be expected on the basis of Bohr's atomic theory, as McLennan has already pointed out. The energy lost by the electrons at these collisions is radiated out as the many-lined spectrum of mercury. It also appears that although ionisation of mercury vapour at 4·9 volts is not definitely disproved, it is certainly much less complete than the ionisation taking place at 10 volts. A. W.

1275. *Theory of the Kathode Fall of Potential.* **H. A. Wilson.** (Phys. Rev. 8. pp. 227–237, Sept., 1916.)—The theory of the kathode fall of potential and Crookes' dark space (based on ionisation by collisions of electrons and positive ions with the gas molecules and by the impact of ions on the kathode) is discussed and is shown to be capable of accounting for the main facts. A brief statement of the experimental results of investigators on the kathode-fall is given, and the remainder of the paper is mainly of a mathematical nature. A. E. G.

1276. *Action of Calcium in a Discharge Tube.* **H. B. C. Allison.** (Phys. Rev. 7. p. 688, June, 1916. Abstract of paper read before Am. Phys. Soc., April, 1916.)—A Plücker tube of the usual type about 8 in. in length, and having a capillary connecting the two electrode chambers is used. The electrodes are Al rods mounted on Pt-wires. In one of the electrode chambers some calcium chips are placed before the electrode is sealed into the tube. The usual lamp exhaust is given, and the tube filled with argon of at least 99·8 % purity. After washing out the tube twice it is sealed off at 2 mm. pressure and connected with a high-voltage transformer. A spectroscope having been put in position, the spectrum is observed to be a combination of argon lines and nitrogen bands, with four prominent hydrogen lines. As the tube continues to run the nitrogen disappears first and then the hydrogen, until only the pure argon spectrum remains. During this time the calcium chips are in the path of the discharge, but not in contact with the electrode. The tube is then inverted, and shortly afterwards the hydrogen lines appear as brilliantly as at first. The calcium is then in contact with the electrode. Upon returning to the original position the clean-up of the hydrogen again takes place. It is possible to repeat this reversal a large number of times, but so long as any calcium remains in contact with the electrode, hydrogen is always present in the spectrum. This is undoubtedly due to the formation of calcium hydride in the first position, and its subsequent decomposition when in contact with the electrode. A. E. G.

1277. *Tungsten Arc under Pressure.* **G. P. Luckey.** (Frank. Inst., J. 182. pp. 407–409, Sept., 1916. Electrician, 77. p. 947, Sept. 29, 1916.)—Describes experiments undertaken primarily for the purpose of determining

whether the temperature of melting tungsten showed a marked change under pressure. For this purpose a tungsten arc was used, and the melting-point of tungsten in an atmosphere of nitrogen was determined for pressures up to 35 atmos. The red black-body temperatures of the melting tungsten for $\lambda = 0{\cdot}661\,\mu$ were measured by means of a Holborn-Kurlbaum pyrometer, the values used for the absorption coefficient of tungsten in computing the true temperature being obtained by extrapolating from values obtained by Worthing for temperatures up to 3200° K. [see Abs. 576 (1916)]. The results of the melting-point determinations are given in the table. Above 12 atmos. rather large uncertainties in the determination of the melting-point were introduced by the distortion of the image due to the refraction of the heated gases in the neighbourhood of the arc.

APPARENT MELTING-POINT OF TUNGSTEN UNDER PRESSURE.

Pressure (Atmos.).	Red Black-body Temperature $\lambda = 0{\cdot}661\,\mu$.	True Temperatures.
1	3138 °K.	3623 °K.
4	3129	3611
8	3116	3594
11	3113	3590
14	3107	3582
18	3099	3572
21	3092	3562
28	3093	3564

At the point where the main arc discharge centres on the electrodes of the arc, a temperature much higher than that of the surrounding melted tungsten was noticed. The temperature of this area varied with the pressure, the current through the arc, and the area over which the discharge took place. Measurements of the highest attainable red black-body temperature were made of this area at different pressures, and the values found are given in the paper. It is considered doubtful whether this temperature can be assumed to be the boiling-point of tungsten. It is more probable that it represents some temperature lying between the melting-point and the boiling-point. Measurements were also made of the electrical characteristics of the tungsten arc in nitrogen under pressures from 1 to 30 atmos. J. W. T. W.

1278. *Electric Discharge in a Transverse Magnetic Field.* **D. N. Mallik** and **A. B. Das.** (Phil. Mag. 32. pp. 50–65, July, 1916.)—In previous papers the behaviour of an electric discharge in a tube of De La Rive's pattern under gradually decreasing pressure has been discussed and a theoretical explanation attempted [Abs. 224 (1913)]. In the present work the behaviour of the discharge when the rotating stage is passed is studied in detail both experimentally and mathematically. The paper is not suitable for abstraction, and for further details the original should be consulted. T. H.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1279. *Inductance of Four-terminal Resistance Standards.* **F. B. Silsbee.** (Bureau of Standards, Bull. 13. pp. 375–422, 1916 [Sci. Papers, No. 281]. Electrician, 78, p. 192, Nov. 10, 1916. Abstract.)—A study of the various methods of measuring the time-constants of four-terminal resistance

standards, which are classified into two main types, viz. (1) those in which the working material is formed into a *closed* circuit of as little self-inductance as possible, and the potential leads kept free from all inductive effects, and (2) those in which the potential leads are placed as close as possible to this working resistance so that the mutual inductance of the lead and the resistance is nearly equal and opposite to the self-inductance of the resistance. The close analogy between four-terminal resistances (or "shunts") and mutual inductances is used, and the causes of phase defects are pointed out, methods of avoiding or minimising these sources of error being suggested. Measurements on the inductances of shunts are divided into two classes: First, relative measurements in which the difference in time-constant of two shunts is determined in terms of known quantities; and second, absolute measurements in which the time-constant of a single shunt is completely determined. Of the many relative methods available, two are considered in detail with diagrams of connections, and the results of measurements made by means of them are given in the paper. The best method for the absolute determination of the inductances of shunts is by comparison with some four-terminal standard whose inductance can be computed from the dimensions. This method, however, is open to the objection that in the computed standard the current distribution, end effects, etc., may not be such as are assumed in the mathematical theory. Each type of standard is considered separately with a view to these sources of error, and three distinct types were used for the absolute determinations, as well as two other methods recently proposed in which there is no dependance on computation. The formulæ for various arrangements of tubular shunts are deduced from a new point of view, and put in a suitable form for computation. The time-constants of a number of shunts at the Bureau of Standards and Harvard University were determined by these methods to within one or two-tenths of a microsecond, so that these may now be used as standards for the calibration of other shunts. The inductance, and susceptibility to stray fields, of a number of commercial types of shunt were measured, and in some cases a change of resistance in the presence of the external field was detected.

J. W. T. W.

1280. *Volume Effect in the Silver Voltameter.* **E. B. Rosa** and **G. W. Vinal.** (Bureau of Standards, Bull. 13. pp. 447–457, 1916 [Sci. Papers, No. 283].)—Misunderstanding has arisen concerning the volume effect in the silver voltameter, and some writers have even questioned its reality. A large quantity of data is therefore given to prove the existence of the effect and to explain the cause of it. The results are divided into three classes. The first class includes a number of voltameter determinations made with the ordinary commercially pure silver nitrate. In the second class the salt used was tested by means of potassium permanganate for reducing substances and was also tested for acidity and found satisfactory. The third class of results includes cases in which the electrolyte was purposely contaminated. The forms of voltameter used were the porous-cup, the Kohlrausch, the siphon, the filter-paper form, and the Smith form. In the case of pure electrolytes, the observations show that there is no tendency whatever for the deposit of silver to be larger in the large voltameter. In the case of purposely contaminated electrolytes, the deposits in the larger voltameters were always considerably in excess. When the electrolytes made from purchased salt were used the deposits in the large-size voltameters were also always greater than in the small size. The general conclusions drawn are, that no matter

what the form of voltameter, if the electrolyte is pure there will be no difference in the mass of the deposits owing to the difference in volume of electrolyte employed, but if the electrolytes are impure there will be a difference, the volume effect being caused by impurities in the electrolyte. The difference is believed to be due to the presence of colloids in the impure solutions. F. E. S.

1281. *Electric Dilation of Solid Insulators in a Direction normal to the Electric Field.* **L. Bouchet.** (Comptes Rendus, 163. pp. 169–171, Aug. 14, 1916.)—Righi, Quincke, and more recently Cantone and Pozanni, have measured the dilation of glass under the influence of the electric field, but their results are discordant. The experiments with glass are now repeated and are supplemented with others on ebonite and paraffin. The apparatus employed is briefly described, and a table showing the results obtained is given. With all the substances it is found that on exciting the field a dilation occurs which varies with the nature of the solid and the duration of the charge. It is also shown that the dilations increase at the same time as the inverse of Young's modulus, and in the case of ebonite the extensions are sensibly proportional to 1/E. This result makes it appear that there is a connection between the electric deformation and the modulus of elasticity. External action, such as electrostatic pressure, does not produce any sensible effect upon the elongation of the insulator. A. E. G.

1282. *Mutual Inductance between a Helix and a Coaxial Circle and Coaxial Cylindrical Current-sheet.* **K. Terazawa.** (Tôhoku Math. J. 10. pp. 73–80, Aug., 1916.)—In numerous papers Nagaoka has shown how the mutual inductance between coaxial solenoids can be rapidly computed by means of formulæ involving Jacobi's q-series. The author proves that the mutual inductance between a helical coil and a coaxial cylindrical current-sheet can be rapidly computed in the same way. He takes $x = b \cos \phi$, $y = b \sin \phi$, $z = p\phi$ as the equation to the helix and $x = a \cos \theta$, $y = a \sin \theta$, and $z = c$ as the equation to the circle.

If $2l$ be the length of the helix and the distance between the middle point of the helix and the centre of the circle be d, he finds that $M = 2ab/p\,[T(d + l) - T(d - l]$, where $T(x)$ is a certain integral which can be evaluated rapidly by Nagaoka's method. By integrating this equation the mutual inductance between a helix and a cylindrical current-sheet is easily found. A. R.

1283. *New Method of producing Stationary A.C. Curves with the Braun Tube.* **C. H. v. Bressler.** (Phys. Zeits. 17. pp. 349–352, Aug. 1, 1916.)—The author has worked out a new method by means of which accurate a.c. curves, which are stationary, can be produced on the screen of a Braun tube. One branch in a balanced bridge consists of a wire fastened to the circumference of a rotating disc, with which a brush makes rubbing contact. The disc is mounted on the axle of a synchronous motor. In the bridge, in which the deflecting coils lie, periodic current-changes are produced which are proportional to the time. The curves can be measured directly or they can be photographed. I. W.

1284. *Sensitivity and Magnetic Shielding Tests of a Thomson Galvanometer or Use in Radiometry.* **W. W. Coblentz.** (Bureau of Standards, Bull. 13. pp. 423–446, 1916 [Sci. Papers No. 282].)—Describes an investigation of the force exerted by various galvanometer coils as compared with a set of three

coils used as standards. Some of the coils were wound according to theoretical requirements, while others were wound empirically. The behaviour of any coil under test was determined by observing the deflection produced by a given current as compared with the deflection produced by the same current when passed through the standard coils. Numerical data are given relating to the force exerted by coils having various resistances. A simple 6-ohm coil is described, wound with a single size of wire (No. 28), which was found to be very efficient. A 9-ohm coil is also described, which is very efficient, and is well adapted to be used with the Bi-Ag thermopiles previously described [see Abs. 1121 (1915)]. A comparison is made of various astatic magnet systems, and data are given showing the importance of using small mirrors in order to increase the sensitivity. Experiments are described on shielding the galvanometer needle from external magnetic disturbances. The galvanometer coils are mounted in cavities cut into blocks of Swedish iron, which reduce the air space and act as a magnetic shield. This elimination of convection currents greatly improves the steadiness of the needle system. Various shields are described, consisting of laminated cylinders made from transformer iron and solid cylindrical shells cut from wrought-iron gas pipe. By embedding the galvanometer coils in blocks of Swedish iron, which are surrounded by cylindrical shells of transformer iron and of wrought iron, the effect of external magnetic perturbations upon the astatic needle system is easily reduced to 1/2000 of its original value. Experiments on a vacuum galvanometer are described, in which a sensitivity was attained which is more than ten times that used in the author's previous work on stellar radiation [Abs. 540 (1915)]. The paper concludes with an appendix on the use of vacuum thermopiles. J. W. T. W.

1285. *Resonance Method for Measuring the Phase-difference of Condensers.* **H. L. Dodge.** (Phys. Rev. 7. pp. 584–585, May, 1916. Abstract of paper read before the Am. Phys. Soc.)—When an alternating e.m.f. is impressed upon a condenser the resulting current does not lead the e.m.f. by the theoretical 90 deg. The angle by which the current lags behind the theoretical value is known as the phase-difference of the condenser. It is possible to determine this angle from data obtained in the experimental study of current resonance. A coil of inductance L, resistance r, and impedance z is arranged to be connected in parallel with a number of paper condensers of the telephone type of nominally equal capacity. An alternating e.m.f. being applied the values of the total current, the coil current, and the condenser current are read as the condensers are introduced one by one. The coil current will remain constant, the condenser current will increase uniformly, while the total current will decrease, pass through a minimum value, and then increase. If several sets of these values are chosen and the vector diagram of currents be constructed, it is seen that if the phase-difference of the condensers is to be zero the minimum total current must be exactly equal to the projection of the coil current upon the voltage axis. As a matter of fact the minimum total current is larger by an amount which varies with the magnitude of the phase-difference. To obtain the phase-difference proceed as follows:—Draw the voltage axis. From the constants of the coil determine the angle by which the coil current lags behind the voltage and plot to scale the vector representing the coil current. With the origin as centre and radius equal to the minimum value of the total current describe an arc reaching a short distance each side of the axis of reference. From the extremity of the coil current vector draw a line tangent to this arc. The angle which this line makes with

the reference axis is the power-factor angle of the condensers. The difference between this angle and 90 deg. is the phase-difference of the condensers. It is also given by the formula $\cos^{-1}(r/z) - \cos^{-1}(I_L/I_T)$, where I_L is the coil current and I_T the minimum value of the total current. A sine-wave e.m.f. has been assumed. If higher harmonics are present their effect will be to increase the apparent value of the phase-difference, but their effect may be reduced by the introduction of inductance in series with the parallel circuit.

The method is not proposed as one possessing any great accuracy. It is, however, of some theoretical interest, and has proved of value in a laboratory where students in studying the alternating-current circuit use the commercial paper condenser. [See Abs. 323B (1912).] A. W.

1286. *Arrangement for Obtaining Constant High Potentials.* **A. W. Hull.** (Phys. Rev. 7. pp. 405–407, March, 1916. Rev. Élec. 26. pp. 250–251, Oct. 20, 1916. Also see Gen. El. Rev. 19. pp. 173–181, March, 1916.)—Gives two schemes of connections for obtaining, with the aid of two kenotrons, constant high potentials, above and below 50,000 volts respectively. With alternating current of frequency 2000 per sec. at 150 volts the arrangement is able to furnish 5 kw. of direct-current energy at pressures between 10,000 and 100,000 volts with a pressure variation less than 1 %. L. H. W.

ALTERNATING CURRENTS AND MAGNETISM.

1287. *Ferromagnetic Substances and Crystals in the Light of Ewing's Theory.* **K. Honda** and **J. Ôkubo.** (Tôhoku Univ., Sci. Reports, 5. pp. 153–214, Aug., 1916.)—Ewing's theory is taken as a basis and is treated mathematically, starting with the two-dimensional case. The force on an elementary magnet at the middle of a square space-lattice, on which lie eight other equal elementary magnets, is calculated in terms of the external field, the length of the square, the pole strength and pole distance. The magnetisation of a single complex is then discussed, and the curve of magnetisation is deduced and it agrees with the experimental one. Equations are also obtained which give the hysteresis loop. The loop thus obtained possesses the characteristics shown by those for iron, nickel, and cobalt, but it displays too much residual magnetism. The theory is next applied to the case of crystal magnetism, and the results are compared with the experimental results of Weiss, Kunz, and Quittner. Certain considerations show that complicated features of magnetisation as observed in magnetite and pyrrhotine are due to distortions of the regular space-lattice. The possession by pyrrhotine of directions of easy and difficult magnetisation in the magnetic plane can be explained by assuming that on account of the deformed configuration of molecules in the hexagonal space-lattice, the mutual action between the magnets in the different rows is very small in comparison with that between the magnets in the same row. It is concluded that the magnetic properties of these crystals can be explained by assuming a cubic space-lattice for magnetite and a hexagonal one for pyrrhotine; no other forces than the mutual magnetic action between the molecules are required to explain the magnetic properties of these crystals. Finally, the existence of the molecular field, put forward by Weiss, is not consistent with the observed facts. G. E. A.

1288. *Paramagnetism.* **R. Gans.** (Ann. d. Physik, 50. 2. pp. 163–198, June 15, 1916.)—Mathematical. In this paper the author goes into greater detail [see Abs. 721 (1916)] in order to show how the more carefully worked-

out theory is capable of representing quantitatively the specific susceptibility as a function of the temperature. With regard to the susceptibility at very low temperatures, it is found that in the neighbourhood of absolute zero the specific susceptibility varies as the seventh power of the absolute temperature. The values found for the magnetic moment per gm.-molecule per magnetic atom are, in most cases, nearly whole numbers, as is demanded by Weiss's theory, but this is not the case for $Fe_2(SO_4)_3$ and for $MnSO_4$. The values found for the molecular field are considerably greater than 10^4 gauss.

G. E. A.

1289. *Magnetic Shielding of Large Spaces.* **E. Wilson** and **J. W. Nicholson.** (Roy. Soc., Proc. 92. pp. 529–549, Sept. 1, 1916.)—Starting from Maxwell's expression for the field inside a spherical shell, Rücker's results are first discussed, and it is pointed out that, as regards the problem of maximum shielding for a given amount of material Rücker showed that there is no "best arrangement" of two shells unless the volume of the material exceeds one-hundredth of the volume of the space enclosed. In general, for permeability μ, a shell should not be laminated if its thickness is smaller than the fraction $3/2\mu$ of its radius. A theory of shielding by means of a series of shells is then worked out, and in accordance with the results of this theory a shield was designed consisting of four shells, the inner diameter of the smallest being 22 in. To measure the weak field inside the shells, an inductor rotated by hand was used in conjunction with a ballistic galvanometer. By means of this method a field of order 3×10^{-3} was measured; this was the field inside a space of radius 30 cm., surrounded by 1273 kg. of high-permeability dynamo-magnet steel.

It is now possible to examine the behaviour of iron under practically no magnetic force. G. E. A.

1290. *Hall and Corbino Effects.* **A. K. Chapman.** (Phil. Mag. 32. pp. 303–326, Sept., 1916.)—The variations of the Corbino-effect with the magnetic field have been studied in a number of metals and alloys, and these variations compared with measurements of the Hall-effect in a disc exactly similar to the one used for the Corbino-effect. The experimental method used was that described by Adams and Chapman [Abs. 120 (1915)]. With bismuth, both effects decrease very quickly with increasing field, the Corbino-effect the more rapidly. Various authors, among them v. Ettingshausen and Nernst, have found the sign of the Hall-effect in certain Bi-Sn alloys to be reversed with increasing field. With a Bi-Sn alloy containing about 1 % of tin, the author finds that both effects decrease rapidly with increasing field, the sign being that of the effect in Bi; the two curves are nearly parallel, the Corbino-effect being the smaller and falling to zero at H = 8910, where the Hall coefficient has the value 1550 referred to copper. When the alloy contains about 2 % tin, the curves are no longer parallel; the Corbino-effect has a value 4187, and the Hall-effect 3000 times that of copper for a field of 250. The former falls off the more rapidly, crosses the Hall-effect curve at a field of 4250, becomes zero at a field of 7900, and reaches a value of —291 at 9110; on the other hand, the Hall curve goes to zero at 9325 and is —184 at a field of 10,450. It is regarded as certain that the reversal obtained in the Corbino curve is not due to the coexistence of the Hall and Ettingshausen effects. Three nickel discs of different thicknesses were investigated, the results showing the Corbino-effect to be independent of the thickness of the disc employed.

In the case of a disc of Norway iron, a remarkable phenomenon appeared

at low fields. The value of m/H is zero up to a field of about 760, rises to a sharp maximum at 950, falls to half the max. value at 1500, and then decreases slowly as the field increases to 10,000, the strongest field used. When the investigation was pursued to values of H below 300, the Corbino-effect was found to undergo reversal; this is the first time that such reversal has been observed in a pure metal. T. H. P.

1291. *Determination of the Constant of a Solenoid.* **S. R. Williams.** (Frank. Inst., J. 182. pp. 353–362, Sept., 1916. Paper read before the Acad. of Science, Columbia, Ohio, Nov., 1914.)—Describes a method for determining the constant (S) of a solenoid experimentally. The solenoid is arranged concentrically with a standard coil (constant G) and a search coil connected to a ballistic galvanometer is placed at their common centre. The solenoid and standard coil are first connected so that a current I passes round them in the same direction and the throw, d_1, of the galvanometer is observed when the current is broken. The current, I, is then reversed round one coil and the throw d_2 observed on breaking. Then, $S = G(d_2 + d_1)/(d_2 - d_1)$. The advantages of the method are that it is not necessary to know the inductive area of the search coil nor the value of the current I; an ammeter is only required to see that the current has the same value when the throws are observed. As a standard the coil of a tangent galvanometer, preferably of the Helmholtz type, may be used. The author, however, recommends a solenoid wound on a non-magnetic "Bakelite" rod, and in the manner described by Jenkins [Abs. 563 (1914)]. He points out, however, that the windings in solenoids are usually much closer at the centre than at the ends. The number of turns per cm. used in computing the constant is generally obtained by dividing the total turns by the length of the solenoid. There is then a discrepancy between the calculated and the experimentally determined values. If the number of turns per cm. for different portions of the coil be determined and their effects upon the field at the centre be separately calculated, then the value of the constant measured experimentally differs from that computed by less than 1 part in 1000. L. L.

1292. *Effects of Magnetisation on the Length of a 35·25 % Nickel Steel.* **A. W. Gray, D. H. Sweet,** and **L. W. Schad.** (Phys. Rev. 7. p. 684, June, 1916. Abstract of paper read before the Am. Phys. Soc., April, 1916.)—By combined magnetic and thermal treatment between the temperatures −75° and 300° C. a permanent increase in length of this alloy of 55 microns per metre was obtained at room temperature. Considerable elongation had previously taken place in the specimen. This length change is in the same direction as that produced in Guillaume's ageing process but is far more rapid. Guillaume found that a hot forged bar left to itself at room temperature for 13 years showed an elongation of 66 microns per metre.

Measurements of linear magnetostriction at temperatures between the same limits have confirmed and extended the observations of Nagaoka, Honda, and Shimizu. Complete magnetostriction cycles showing hysteresis have been taken up to the temperature at which magnetostriction vanishes. Magnetic elongations exceeding 45 microns per metre have been measured. This appears to be the largest longitudinal magnetostriction effect observed for any substance. L. L.

1293. *Sensitive Magnometer.* **P. E. Shaw** and **C. Hayes.** (Phys. Soc., Proc. 28. pp. 293–300; Disc., 300–301, Aug., 1916.)—A torsion balance of special delicacy designed for gravitation measurements has recently been

described by Shaw [Abs. 860 (1916)], in which two small silver balls are hung by fine wires from a short beam, the system being in a low vacuum of about 15 mm. pressure. In the course of heating the apparatus it was found that the silver balls acquired a permanent magnetisation from the field of the helix used for warming up the chamber. Experiments were then made with a solenoid oriented with its axis perpendicular to the magnetic axis of a silver sphere, and readings of scale deflections made for various currents in the solenoid, and for various distances. Reference is made to the work of Honda on the susceptibility of silver; also to investigations by A. P. Wills and Fleming and Dewar, the latter at low temperatures and high fields. This torsion balance is claimed to be 10^6 times as sensitive as any known to have been used previously in this kind of work. The magnetic properties of silver are ascertained for fields as weak as 1–10 gauss. The material used was found to have a distinct retentivity, presumably due to the small trace of iron impurity, 30 in 1,000,000. Measurements were also made of the relation of the susceptibility of the silver to the field used, indicating the differences introduced by the mixture of iron and silver on the properties of these metals when used separately. It is suggested that the apparatus furnishes a promising means of making a systematic investigation of the magnetism of feebly magnetic materials, even for weak fields. C. P. B.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1294. *Radiologic Dosimetry: Theoretic and Experimental Researches.* **R. Ledoux-Lebard** and **A. Dauvillier.** (Comptes Rendus, 163. pp. 171–174, Aug. 14, 1916.)—The method of exciting Röntgen tubes previously described [Abs. 726 (1916)] has the disadvantage that the homogeneous kathode rays produced give rise to a heterogeneous radiation so that the analysis of the radiation is always difficult and the precise dose not easy to determine. It is now proposed to make use of special tubes which produce a monochromatic radiation or, at least, a spectrum composed of only a very small number of rays. A diagram of a tube based upon principles which are enunciated is shown and briefly described. As it appears probable that Röntgen rays of different wave-length do not possess identical therapeutic properties a series of tubes of this class would make it possible, in each clinical case, to choose the most efficacious radiation. Since continuous current is used the working conditions are definite, and so the radiologist can rely upon always obtaining an identical radiation. So far as the dose is concerned the only measures required to be made are the intensity and the time. A. E. G.

1295. *Induction Coil utilising the Inverse Current.* **A. C. Gunstone.** (Röntgen Soc., J. 12. pp. 62–65; Disc., 65–67, July, 1916.)—The induction coil used is provided with two primary windings with a central tapping, and the Hg interrupter is fitted with four contacts so arranged that when the jet leaves one contact and passes on to the next contact, the current flowing in one primary winding is broken, and then made again in the other winding. The iron core is thus carried through a complete cycle of positive and negative magnetisation. Oscillograms taken with the oscilloscope are reproduced showing the effect of the arrangement on the impulses. In the *discussion*, the author's device was unfavourably criticised by several speakers, it being pointed out that the inverse current was undesirable; and this the **Author** admitted, only he had found it easier to utilise the inverse current than to eliminate it. L. H. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1296. *Facts and Conclusions on the Number and Mode of Union of Electrons in the Hydrogen Atom.* **J. Stark.** (Ann. d. Physik, 50. 2. pp. 53–88, June 15, 1916.)—This very comprehensive paper is divided into eight sections. The first deals exhaustively with the present standpoint of chemists and physicists on the problem of atomic structure. The second part treats of ionisation and chemical union of the hydrogen atom. The latter is found capable of assuming different equilibrium conditions, *e.g.* as a neutral atom, as a positive atomic ion, as a negative atomic ion, and as a constituent of a chemical molecule. These facts favour the supposition that the vibration of the electrically charged parts of the hydrogen atom possess different frequencies in the different states, and, that the spectra of the hydrogen atom will in consequence also differ from each other. Three distinct spectra have been determined with certainty : (1) The series spectrum which includes the well-known lines of the Balmer series in the visible part ; (2) the band spectrum which in the visible and especially in the blue and ultra-violet regions possesses numerous lines, some apparently irregular and others of a banded character ; (3) the Schumann spectra which comprises very numerous lines between 1600 and 1000 Å. in the extreme ultra-violet. The above are dealt with in Part III which considers the various hydrogen spectra and their carriers. The fourth and fifth sections investigate the number and mode of arrangement of the electrons in the H positive atomion and the neutral hydrogen atom respectively. Part VI is a study of the velocity of the hydrogen electrons. Here it is shown why the velocities of chemical reactions in which the valency electrons play the leading rôle are functions of the temperature. Part VII deals with elementary regularities in the hydrogen series, and the connection between the various components. Finally Part VIII considers the deformation of atomic structure. H. H. Ho.

1297. *Volatilisation of Platinum.* **G. K. Burgess** and **R. G. Waltenberg.** (Bureau of Standards, Bull. 13. pp. 365–373, 1916 [Sci. Papers, No. 280].)—Further experiments [see Abs. 1625 (1914), 1349 (1915)] show that platinum ware in the form of crucibles of whatever degree of purity behaves, with respect to gain or loss of weight, on heating in air at ordinary atmospheric pressure in a manner characteristic only of the temperature of heating. Each impurity, such as Ir, Rh, or Fe, appears to exert its effect on the volatilisation independently, but the loss on heating is negligible below 900° with crucibles of all degrees of purity containing Ir, Rh, Fe, and Si (up to at least 3 % Ir). Below this temperature there may even be a slight gain in weight on heating Pt, owing to the Fe diffusing to the surface and undergoing oxidation, and at higher temperatures the presence of Fe will lower the volatilisation loss by amounts depending on the quantity of Fe present ; there appears to be no platinum made which does not contain some iron. The volatilisation of platinum containing Rh is less than that of pure Pt at all temperatures above 900°. The volatilisation of Pt containing Ir is, above 900°, very much greater than that of pure Pt, and increases with the content of Ir and with rise of temperature. Over the temperature-range, 700–1200°, the order of heating—rising or falling temperatures—appears to make no

appreciable difference to the volatilisation. In an oxidising atmosphere at temperatures of the order of 1000° platinum in presence of, but not in contact with, silica appears to take up small quantities of this substance.

The loss in crucible weight due to the solution of matter in hydrochloric acid after heating is variable and depends on the crucible, but may be large; this loss is relatively greater at low than at high temperatures. All of the above losses, caused by heating, treatment with acid, and diffusion of the iron, apparently continue with undiminished magnitude after the first treatment, which is usually erratic; eventually, of course, the concentration of Fe, etc., must become appreciably lessened. T. H. P.

1298. *Carbides of Aluminium, Nickel, and Copper.* **E. Briner** and **R. Senglet.** (Journ. Chim. Phys. 13. pp. 351–376, Nov. 15, 1915.)—Part of an investigation of chemical kinetics, beginning with calcium carbide, and concerning the formation of the carbides from the elements and their decomposition. The carbide Al_4C_3 is studied in a resistance furnace, a tube of Berlin porcelain wound with nichrome wire; for working in a vacuum, a tube of syloxide (impure silica) is pushed into the furnace tube. The reaction $Al_4C_3 \rightarrow Al_4 + C_3$ is quite reversible; the compound is exothermic, but the reactive velocity has not been determined as the decomposition is irregular. When the carbide is heated in air, CO_2 and Al_2O_3 are formed; in vacuum dissociation takes place, but some suboxide seems to be formed and some Al to disappear. Oxidation probably following dissociation is observed at 540° already, and at lower temperature decomposition is more rapid in air than in a vacuum; at 900° the vacuum reaction is the more rapid. The nickel carbide Ni_3C was formed by heating the elements above 1550°, the melting-point of nickel, and quenching the product in cold water. Heating of the mixture in a Méker burner at 1500° and at 1600° hardly changed the microstructure of the fused mass unless the heating to 1600° was continued for 4 hours; the optimum temperature for the formation is found to be 2100°, as Ruff and Martin had observed, when the reaction is completed in a few minutes. Continued heating dissociates the carbide slowly at 900°, rapidly at 1600°. The formation of the carbide is endothermic, but the reaction becomes exothermic at high temperature. When nickel and carbon are probably both in the gaseous atomic state, the formation at 2100° may already be exothermic. The experiments with copper and carbon were inconclusive; the elements seem to form an endothermic carbide in a Moissan furnace, but it dissociates again. H. B.

1299. *Manganese-Bismuth Alloys.* **E. Bekier.** (Internat. Zeits. Metallog., 7. pp. 83–92, 1915.)—The experiments were made with the purest manganese obtainable, which, however, contained 1·6 % Fe and 1·5 % Si. The author finds that powdered Mn is dissolved by Bi, when fused in unglazed porcelain in a reducing atmosphere, leaving the impurities behind, and that pure Mn (freed from Bi by heating or by treatment with boiling mercury) can be prepared in this way; but he does not speak of experiments with this pure Mn. Large percentages (70 at. %) of Mn are soluble in Bi (the converse does not hold). There is a eutectic point close to pure Bi, and crystals of a compound have been obtained, but its composition (intermediate between Mn_2Bi and MnBi) has not been settled. Reference is made to the Berlin dissertations of Wedekind and of Dieckmann (both 1911). H. B.

1300. *Contribution to the Study of the Cementation of Iron.* **S. A. Fechtchenko-Tchopovsky.** (Rev. de la Soc. russe de Métall. 1. pp. 245–

310, 1914. Rev. de Mét. 12E. pp. 518–522, Dec., 1915.)—The author has made a study of the cementation of soft steel by various carburising materials at different temperatures. In the preparation of wood charcoal for cementation purposes the best material is obtained from hard woods by carbonising at 400° C. for 4 hours. Its grain size should not exceed 3 mn. The carbonising of wood charcoal is a function of the duration of the operation, but diminishes rapidly with the progress of the cementation. Counting from the time the article attains the proper temperature, 10 hours is the max. useful time at 1000° C. Addition of lampblack or leather does not serve any useful purpose, but often has a derogatory effect on the cementation. The operation of cementing is carried out through the medium of the gas CO. Carbonising is most expeditiously affected at a temperature of 900° C. Below this temperature the operation is too slow to be economical, and at higher temperatures the structure of the metal becomes very coarse. Addition of lithium carbonate, sodium carbonate, oxalate and acetate, potassium carbonate, tartrate, chromate, ferri-cyanide, etc., and barium carbonate strongly increase the rate of carbonisation when added to wood charcoal. They have a tendency to produce a peripheral layer of free cementite. Strontium and cobalt carbonates increase the rate of cementation, while sodium and potassium sulphates and chlorides retard the progress of the operation. A table is drawn up showing the relations between the rate of cementation, temperature, and time of the operation when using a mixture of 7 of charcoal to 3 of sodium carbonate. F. C. A. H. L.

1301. *The Pseudo-Eutectic Temperature of Iron-Carbon Alloys.* **O. Ruff** and **W. Bormann.** (Ferrum, 12. pp. 124–126, June, 1915.)—In agreement with Howe the authors call the true eutectic temperature that temperature at which iron (in the form of mixed crystals) and cementite separate solid in the same proportions in which they had existed in the molten mass, whilst the near-eutectic (pseudo-eutectic) temperature is that at which the liquid is simultaneously saturated for mixed crystals and for graphite. When pure iron-carbon alloys are slowly cooled, mixed crystals of iron saturated with cementite and of graphite separate; but the graphite is present in exceedingly small quantities, and is only being produced by the decomposition of cementite. To determine the pseudo-point, hence, a start has to be made with hyper-eutectic alloys containing more than 4·3 % C, and the cooling should be such that any separation of cementite and any retardation in the graphite separation is avoided as much as possible. The iron of the authors contained 4·13 % C, 0·074 Si, 0·006 S, 0·02 P, 0·15 Mn, and 0·005 % Cu; it was melted in a graphite crucible within a resistance furnace at 1250°. The pseudo-eutectic temperature was found to be $1138{\cdot}8 \pm 1°$ C. The point is slightly lowered by the presence of Mn, and raised by that of Si, but is so sharply defined that it might serve as a standard temperature. H. B.

1302. *The Iron-Carbon Equilibrium Diagram.* **O. Ruff.** (Ferrum, 12. pp. 121–123, June, 1915.)—A reply to H. Howe (Ibid. 11. p. 170) who had misunderstood the author on three points. The author did not state that, on the equilibrium-concentration being exceeded, the whole of the cementite should become metastable and tend to separate with subsequent formation of graphite. It is only the cementite in solution which is in excess of the equilibrium-concentration G.K. that separates, this going on until saturation-concentration S.K. is reached. The other points concern the eutectic temperature and calculations, as to which the author follows Gistowsky, and

further the indication of the G.K. line ; the author marks this line (and not the S.K. line) in dashes, although he knows that custom is against him.

H. B.

1303. *Metallographic Studies. Electrolytic Copper.* **M. v. Schwarz.** (Internat. Zeits. Metallog. 7. pp. 124–173, 1915.)—Having accidentally obtained remarkably long and fine copper crystals from an ordinary bath (acid sulphates) by dynamo currents of 0·5 to 5 amps./dm.^{2} on graphitised moulds, keeping the bath perfectly quiet at 0° to 7° C., the author investigated the conditions of crystallisation and methods of metallographic study by photography, etching, polishing, influence of pressure, age, etc. The copper seemed very pure (over 99 % Cu), although technically warm baths, well agitated, are recommended. The crystals are twinned octahedra, whose structure can be recognised by etching. The orientation is at right angles to the kathode surface, and radial with wire kathodes. The grains resulting from etching grow to several hundred times their size on annealing, which also leads to lamination ; on prolonged heating this lamination disappears again. Polishing parallel to the kathode surface also brings out the crystal shape ; electrolytic copper crystals are, however, very sensitive to pressure, also when cut with the finest fret-saw ; the pressure influence is further to be studied. The boundaries of the grains need not be in the amorphous condition ; the substance of the boundary layers is little able to resist chemical and thermal influences. The diagram of deformed metals does not indicate the presence of any amorphous modification, nor does the oriented growth on polished surfaces support this assumption. H. B.

1304. *Alumina Inclusions in Steel.* **A. Sauveur.** (Met. and Chem. Eng. 15. pp. 149–151, Aug. 1, 1916.)—Examination of samples of thermit iron, ingot iron melted with Al, and ingot iron melted with alumina, has entirely confirmed the conclusions of Comstock [Abs. 398 (1916)]. It seems justifiable, therefore, to distinguish alumina from other inclusions which occur in steel by their small size, their dark colouration, and more especially by a complete absence of elongation in the direction of rolling or forging.

F. C. A. H. L.

1305. *Behaviour of Slag Enclosures in Acid Steel.* I. *Influence on the Structure of a Nickel Steel.* **F. Giolitti** and **S. Zublena.** (Internat. Zeits. Metallog. 7. pp. 35–82, 1915.)—The specimens were taken from two ingots of 1 ton each of an acid Siemens-Martin steel, containing 0·38 % C, 0·60 Mn, 0·22 Si, 0·008 S, 0·02 P, and 2·02 % Ni ; also from a very similar steel of 1·98 % Ni. Experiments with basic steels are to follow ; but the authors accentuate that their conclusions so far concern only the nickel steel studied. All the slag enclosures were of the emulsified, light-grey type, observed within the edges of the ferrite and separated from the pearlite crystals. Small prisms of the steel, heated within a porcelain tube in an Heraeus furnace in an atmosphere of CO for 4 hours at 1060°, showed a slight decarburisation, and the enclosures were no longer separated from the pearlite ; in other words, the threads of slag grains seemed to have lost their orienting influence on the ferrite. When the specimens were heated to 1100° and 1190°, the slag grains were no longer surrounded by ferrite. The conclusion drawn from these and other experiments is that the slag enclosures act as centres of crystallisation for the ferrite, and that this is not a direct physical effect, but a result of chemical reactions, the effect being due to the different rates of the oxidation and reduction processes and to the different conditions of unstable equilibrium

between the two solid phases—the steel and the slag enclosures. This view is in accordance with the fact established by the authors, that the activity of the slag with respect to the ferrite can be altered at will within very wide limits, and can be made to disappear and to reappear several times in the same specimen. J. E. Stead suggested in 1909 that moderate amounts of certain slag enclosures need not affect the mechanical strength of a steel. The authors go further, and believe that suitable thermal treatment can, wholly or partly at any rate, eliminate the injurious effects of slag enclosures. References are made particularly to W. Rosenhain and to Hibbard and Oberhoffer. H. B.

1306. *Titanium, Vanadium, and Nitrogen. Influence of Vanadium and Titanium on the Nitrogen Content of Iron and its Alloys.* **N. Tchigevsky** and **N. Blinow.** (Rev. de la Soc. russe de Métall. 1. pp. 636–646, 1914. Rev. de Mét. 12E. pp. 473–475, Dec., 1915.)—The detrimental effect of nitrogen on the mechanical properties of iron and its alloys is indisputable. It has been affirmed that certain elements including V and Ti form nitrides which are insoluble in iron, and can therefore be used as nitrogen eliminators. The author has made an exhaustive study of the nitrides of these two elements, and has shown that it is impossible for them to act as nitrogen eliminators, because not only do the nitrides possess a large temperature range of stability, but in addition they are very soluble in iron. In fact, the presence of these two elements is liable to increase the nitrogen-content of iron and steel. In order to confirm these results a Bessemer steel containing 0·0105 % nitrogen was melted with 1 % ferro-vanadium. The product was found to contain 0·063 % nitrogen. F. C. A. H. L.

1307. *Corrosion of Metals: Third Report to Corrosion Committee of Institute of Metals.* **W. E. Gibbs, R. H. Smith,** and **G. D. Bengough.** (Inst. of Metals, J. 15. pp. 37–163; Disc. and Corres., 164–191, 1916. Engineering, 101. pp. 311–312, March 31, 1916.)—This lengthy monograph deals with the subject under numerous headings entitled: Experiments with stagnant, with undiluted, and with aerated sea-water; Coke and corrosion; Influence of surface condition; Corrosion in solutions other than sea-water; Experiments on the mechanism of corrosion; Bearing of the results upon practical conditions.

The authors' summary alone occupies ten pages, and it is therefore impossible to do more than direct the reader's attention to this continuation of the earlier work [see Abs. 1457 (1914)]. L. H. W.

1308. *New Thermoelectric Method of Studying Allotropic Changes in Iron or other Metals.* **C. Benedicks.** (Iron and Steel Inst., J. 93. pp. 211–220; Corres., 221–223, 1916. Mech. Eng. 37. pp. 406–408, May 26, 1916. Engineering, 101. pp. 633–634, June 30, 1916.)—[See Abs. 625 (1916).]

1309. *Some Problems in Physical Metallurgy at the Bureau of Standards.* **G. K. Burgess.** (Frank. Inst., J. 182. pp. 19–35, July, 1916.)—Deals with the particular problems that have been and are still being attacked at the Bureau of Standards, the view being taken that a considerable number of these will be solved within a reasonable time. L. H. W.

1310. *Decomposition Potentials of Fused Alkali Hydroxides.* **B. Neumann** and **E. Bergve.** (Zeits. Elektrochem. 21. pp. 143–152, April 1, 1915.)—The absolute potentials of K and Na, calculated from the heat of formation of their chlorides, are 3·1 and 2·7 volts according to Wilsmore.

Indirect potential measurements (Lewis) gave K 2·93 and Na 2·72, whilst the electrolysis of fused alkali salts (various authorities) suggested that K was always more electropositive than Na, but more so at high than at low temperatures. The authors find that the combination Na | NaOH fused | Ni in nickel crucibles gave 1·4 volts, the K-couple similarly 1·76 volts, from which the potentials Na | NaOH = 2·0 volts and K | KOH = 2·36 volts would follow at 320°. The combination Na | NaOH | KOH | K, yielding 0·34 to 0·38 volt, was also tried; but all these experiments were not satisfactory. They studied, therefore, the decomposition of the fused hydroxides under different conditions, in presence of air, with addition of peroxide, in a nitrogen atmosphere, and in molecular mixtures of the two hydroxides both in air and in nitrogen. When working in air, the potential curves for the two hydroxides were not parallel, probably because K peroxide is formed during the electrolysis; peroxide was therefore added to the NaOH; then the curves become nearly parallel; this parallelity was maintained in mixtures of the two hydroxides, also in nitrogen atmospheres. Experiments with lithium hydroxide (not pure, nor free from water) failed to give any metallic lithium, even in nitrogen atmosphere, and the potential observed was that of the decomposition of water; the lithia attacked the Ni more than the other caustics did. The following are the final values for the decomposition potentials at various temperatures:—

	180°.	200°.	305°.	335°.	390°.	530°.	640°.
NaOH.....	2·38	2·32	2·25	2·22	2·05	1·62	1·32 volts
KOH	—	2·4	2·36	2·4	2·25	1·8	—

Thus the potential difference K | Na seems to be 0·18 (or 0·15) volt, independent of temperature. There is a decided change in the temperature coefficients, and hence in the curves, at 335°. To explain the peculiarities the authors suggest that the depolarisation by oxygen is more important in the case of potassium, but only below 490° or 440°; at lower temperatures mists of metal-vapour and suboxides may play a part. The solubility of the metal in the fused mass also enters; in the case of Na this solubility becomes pronounced at 335°; hence the electrolysis of caustics for sodium (Castner) is technically conducted below 335°. The investigation also shows why mixtures of the two caustics yield only alloys of the two metals. H. B.

1311. *Decomposition Potentials of Fused Alkali Haloids and Alkaline-earth Chlorides.* **B. Neumann** and **E. Bergve.** (Zeits. Elektrochem. 21. pp. 152–160, April 1, 1915.)—The experiments were made in crucibles of hard carbon, coated inside and outside with a mixture of water-glass and powdered asbestos; porcelain cracked, and nickel was destroyed by the chlorides. The electrodes of Acheson graphite were similarly coated and also the copper leads. The experiments concern LiCl, the chlorides, bromides, and iodides of K and Na and some mixtures of these salts, further the sulphates and sodium carbonate; the salts of the alkaline earths used are the chlorides and further $MgSO_4$. As regards the haloids (both alkali and alkaline-earth), all the decomposition potentials lie on straight lines. As the temperature coefficients of all the K and Na salts examined were of the same order, $1·5 \times 10^{-3}$, those curves were all parallel; the potential difference K | Na seems to be 0·15, independent of temperatures [see preceding Abs.].

The temperature coefficients of the metals of the alkaline-earths are smaller, being of the order $0{\cdot}7 \times 10^{-3}$; hence the curves for the alkalies and the alkline-earths intersect, *e.g.* the $CaCl_2$ curve cuts the NaCl at 750°; the potentials of the alkaline-earth metals are certainly at high temperatures, more electro-positive than potassium, and the series appear reversed; that would account for the contradictory observations of various experimenters. The p.d.'s between chlorine, bromine, and iodine likewise seem to be independent of temperature, and as a consequence the temperature coefficient appears to be characteristic for the groups of the periodic system. As the curves of the decomposition potentials rapidly descend with rising temperature, the affinities between the elements would tend to vanish at: LiCl, 2950°; NaCl, 2640°; KCl, 2720°; NaBr, 2440°; Na_2SO_4, 2000°; K_2SO_4, 2159°, etc. The calculations from the second law of thermodynamics yield for the absolute potentials at room temperature: Li 2·03, Na 2·44, K 2·60 volts. Some of the observed decomposition potentials in volts are: LiCl, 2·62 (630°); NaCl, 2·6 (835°); KCl, 2·8 (810°); NaBr, 2·45 (690°); KBr, 2·6 (690°); KI, 2·2 (630°); K_2SO_4, 2·6 (890°); $CaCl_2$, 2·85 (585°); $SrCl_2$, 3 (615°); $BaCl_2$, 3·05 (650°).

H. B.

1312. *Micro Electro-analyses.* **E. H. Riesenfeld** and **H. F. Möller.** (Zeits. Elektrochem. 21. pp. 137–143, April 1, 1915.)—A description of a first series of determinations made by the authors with their microbalance [see Abs. 1181 (1916)] and interrupted by the war. In the analysis of copper, silver, mercury 5 mgm. could be determined per litre within 0·5 %. That no higher accuracy could be obtained was due chiefly to the difficulties of securing electrodes of constant weight, the weight of the Pt electrodes used fluctuating within those limits owing to gas films and possibly to formation of oxides and hydrides. The other sources of error, such as impurities of reagents (lead in the sulphuric acid; impurities in ordinary alcohol making it unfit for washing), attack of the Pt anode by cyanide (negligible in ordinary analysis, but vital in micro-analysis), incomplete and spongy deposition of the metal, etc., were overcome. The deposit must be left in the solution, and the electrolyte be displaced by water without breaking the circuit. The quantitative analyses are slow, the copper determination requiring 16 hours without stirring, at least 2 hours with stirring. The kathode is best made of coiled wire not more than 0·01 mm. in thickness. Particulars are given of the determination of copper (in 2-N nitric acid, 2 volts, 10 milliamps., 90° C.), silver (same acid and alcohol, 1·35 volts, 4 milliamps., 50° C.), mercury (same acid, 3 volts, 10 milliamps., 0° C.). H. B.

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